METAL

DECEMBER 1936

PROGRESS

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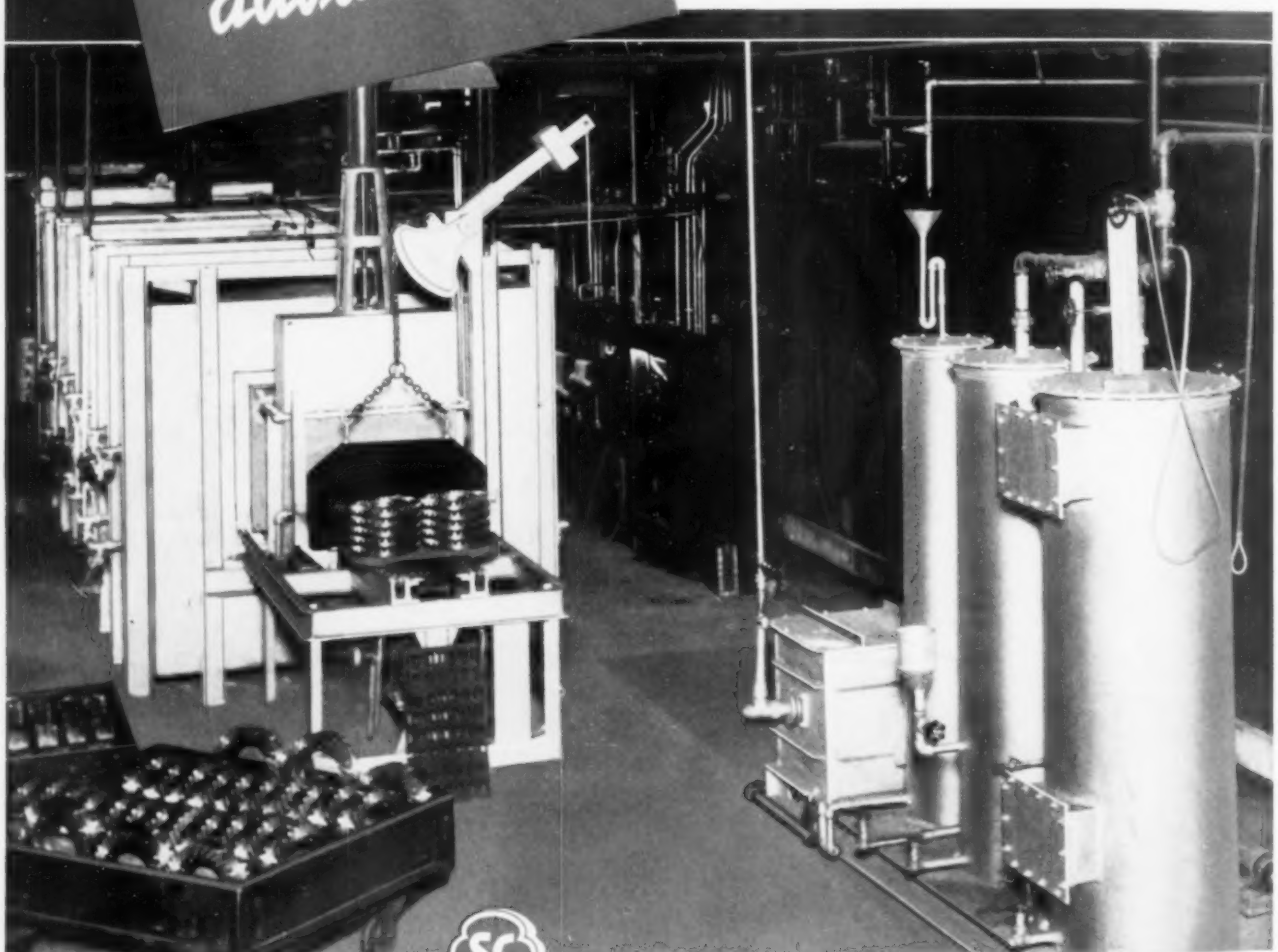

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METAL PROGRESS

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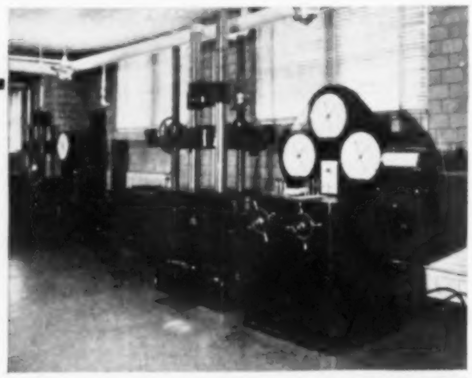

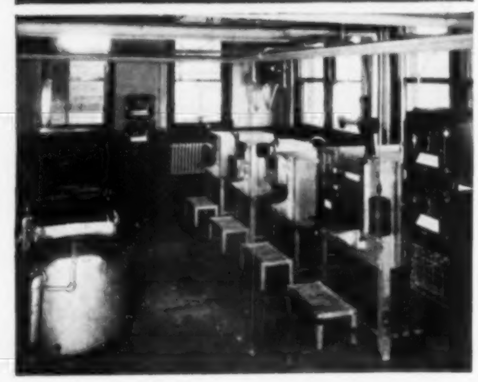

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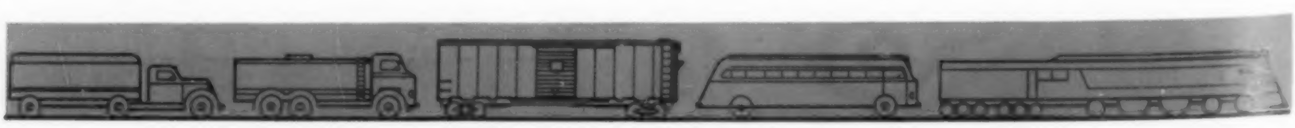

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METAL PROGRESS

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ON CERTAIN ASPECTS OF MACHINABILITY

IT IS rather common knowledge that certain long-time trends are showing their effect on the mutual relationships between management, machine shop and metallurgical department. Notable increases in size, power and rigidity of machinery, improvement in the cutting tools, more uniform metal — all are pushing the machinist to higher and higher levels of "machinable hardness." Large automobile shops have now been in mass production for about 10 years on alloy steel parts testing from Brinell 350 to 450 — metal considered practically unmachinable a generation ago, yet obviously desirable for its high physical properties in such parts as steering arms and knuckles.

However, in most plants the machine shop foreman still has the ascendency, and consequently the management requires the metallurgical department to furnish metal that will cut with the greatest possible ease. Doubtless this is a sound attitude to take when a cost sheet shows three-quarters of the expense to be the conversion of solid metal into chips, or where the loads and stresses in the finished part are nominal and appearance and size are the prime considerations. Metal producers have gone to great pains to improve the machinability of such metal, ranging all the way from fine-grained gear steels to screw machine stock, much of it sold on a guaranteed machinability.

Brass, the original ideal for easy machining, blanking and forming, was used in the first screw machines by New England sewing machine and clock builders before the Civil War, and this metal in both sheet and rod form was improved by adding some lead so long ago that most have forgotten when it happened. Bessemer steel was naturally the raw material for the first steel screws (1871), and it wasn't long before it was noticed that the bars analyzing somewhat higher in sulphur cut much more easily.

But when it comes to further improvements in material already good, special difficulties beset the metal producer, not only because the property of machinability is a complex one, but because conditions in the users' shops differ so widely as to equipment, personnel, and objectives. H. W. Graham has recently described researches conducted continuously for at least 15 years, into all phases of the bessemer process as applied to the manufacture of screw stock. Such a research should have a quick test for machinability; unfortunately such a test is unknown to Mr. Graham, and in his opinion the way to measure the cutting quality of metal is to secure a modern machine tool, put the bars in it, and proceed to cut them! Even then the error in results may be as much as ± 10%. In spite of this handicap to research, we have today on the market, as the result of much patient work by several steel makers, improved bessemer screw stocks which an unprejudiced user would grade at least 20% better in *machinability*, either as hot rolled or cold drawn bars, than the older standards.

A somewhat different aspect of machinability was attacked by L. W. Kempf and his associates in the Aluminum Co. of America, in the development of an easy cutting light alloy. In their laboratory experimentation (outlined in **Metal Progress**, July 1935) they judged the relative excellence of proposed alloy modifications by the size and bulk of the curly chips and the smoothness of the finished surface, rather than power consumption or tool wear, when using a tool set-up that would be satisfactory for brass but not for the wrought aluminum alloys then available. Finally, a strong alloy containing lead, bismuth and copper was fixed upon — each addition contributing in different degree to free cutting properties, the resulting alloy having a good combination of workability, strength or corrosion resistance.

In the article immediately following it is interesting to note that these metallurgists have proven their case for the new alloy 11S exactly as was done for improved bessemer screw stock — by putting the bars in a machine tool and making commercial parts from them. The amount of detail and painstaking work is exceedingly great, and any student of machinability will admire the persistence and thoroughness of this successful investigation of a most intricate problem.

The authors are respectively connected with the Cleveland Research Laboratories and the Edgewater (N. J.) Fabricating Division of Aluminum Co. of America, and the article presents data acquired in production runs on a new alloy known as 11S. A former article in METAL PROGRESS *(July 1935) by Messrs. Kempf and Dean told of its metallurgical development. Early expectations that it would have cutting characteristics clearly superior to aluminum materials previously available are now borne out by extensive experience in plant.*

SCREW MACHINE PERFORMANCE ON NEW ALUMINUM ALLOY

BY L. W. KEMPF AND A. HARTWELL

PRODUCTION COSTS in any fabricating operation are composed of many interrelated factors and any analysis of cost is usually inseparable from the specific accounting system utilized in its deduction. For the purposes of a general discussion, however, it may be stated that the principal items entering into the cost of an article produced by a screw machine are (1) material, (2) machine time, (3) machine labor, (4) separating, cleaning, and inspection, and (5) overhead.

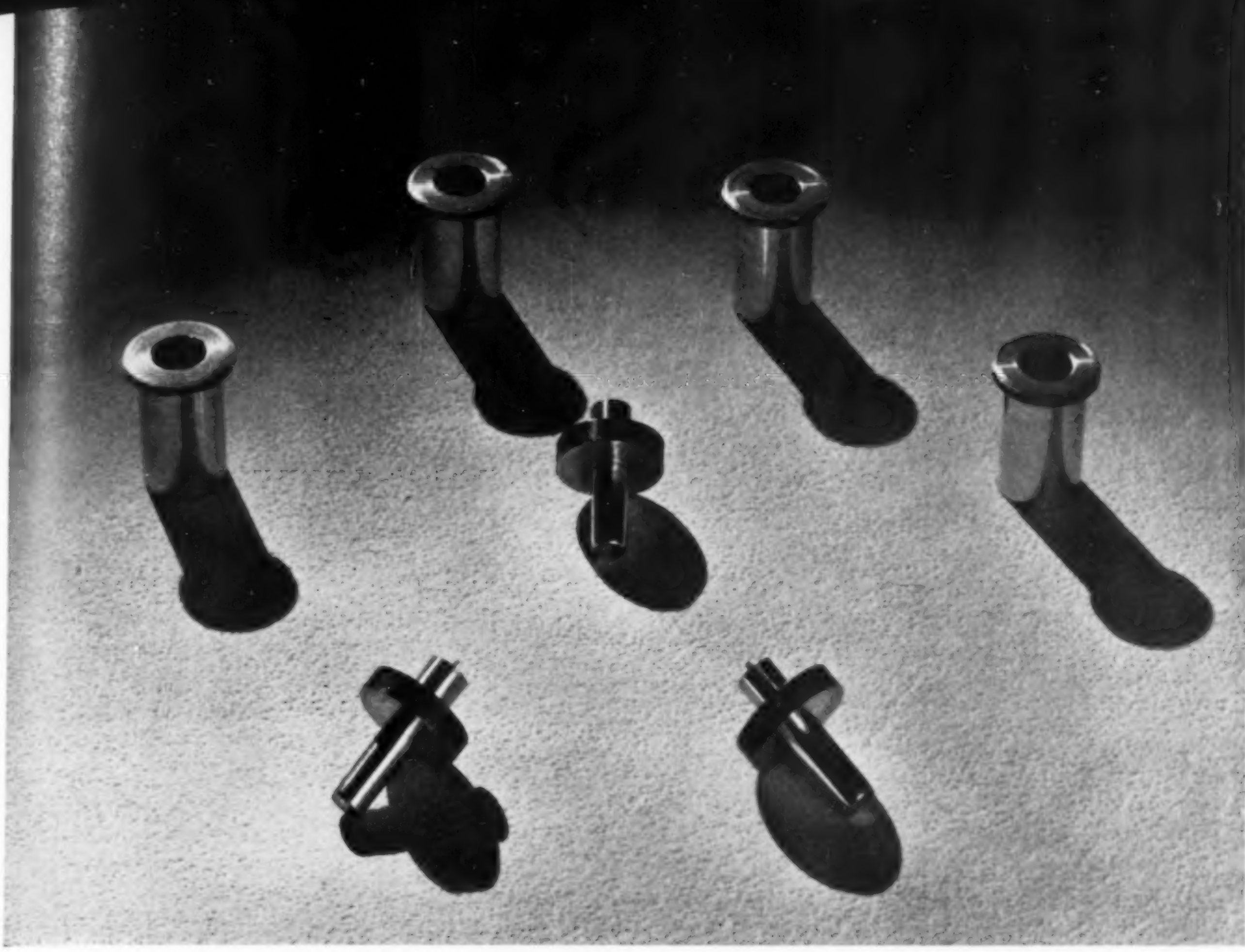
At any specific time, the costs of various materials bear a definite relationship to each other and are fixed. It will suffice for the purpose of this article to state that on a volume basis the cost of aluminum screw machine stock is at the present somewhat less than that of brass. Material cost in this sense must of course be credited the value of the scrap produced in the form of chips and rod ends. This discussion will be limited primarily to the effect of different materials on the second and third items in the cost analysis, namely, machine time and machine labor.

Costs of separating, cleaning, and inspection (fourth item listed) may be quite appreciably affected by some properties of the material, such as the character of the chips and the consequent ease of separating them from the finished pieces. This factor, however, will not be considered here although it may be mentioned in passing that fine chips (characteristic of the new free-cutting aluminum alloys) are much easier to separate from the parts than the stringy, continuous chips from the older aluminum alloys used for screw machine products.

The principal factors affecting the machine time are (1) the spindle speed or, more accurately, the surface speed of the stock, (2) the rate at which the various tools feed into the stock, and (3) the overall time efficiency.

When cutting highly machinable materials such as brass and the strong aluminum alloys, it is usually advisable to run at the highest spindle speeds compatible with a reasonable rate of machine deterioration. The weight of the stock in the spindles is sometimes an important factor in the rate of deterioration of the machine; when this condition obtains, the aluminum alloys of course have a distinct advantage in their low specific gravity.

The rate at which a tool may be fed into the stock is limited by the power required for making the cut, the rigidity of the machine and stock, the character of the chips, the surface finish, dimensional tolerances, rate of tool wear, tool design, and the mechanical interaction of successive tools in a specific setup.



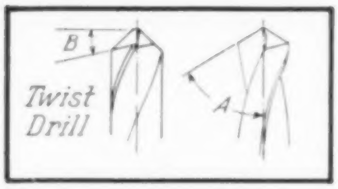
Parts Manufactured in Screw Machine During Preliminary Experiments on Machinability

What is meant by "the overall time efficiency of the machine operation" — or briefly "machine time efficiency" — may need a word of explanation. As an example, the time necessary for machining one piece may be 3 sec. and an order may call for 100,000 pieces. The machine time theoretically required for the production of the order is 300,000 sec. or 83.33 hr., but it is found that the time the machine must be assigned to the job, in order to produce the necessary number of parts, is 119 hr. The overall machine time efficiency is then 70%. The difference between the theoretical and the actual machine time is consumed in tool changes, minor machine repairs and supplying new stock. Obviously the character of the material being machined may have a large effect on the frequency of tool changes and on the amount of fouling of tools and work by the chips, consequently, directly affecting the machine time efficiency.

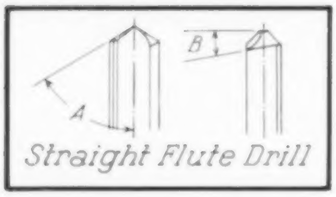
Machine labor may be divided into that required for making the tool setup and that required for attention during the continuous operation of the machine. The character of the material will affect the setup time to some extent, but a quantitative measurement is almost impossible due to variation in shop conditions. It can be said, however, that the more versatile the alloy as regards permissible tool angles, the shorter the setup time. The material being cut, on the other hand, may have a very real effect on the second item (running attention) in the same manner that machine time efficiency is affected.

Of the various factors discussed in the foregoing, the characteristics of the material affect principally tool feeds, machine time efficiency, and that portion of the machine labor designated as "running attention." It appeared desirable, therefore, to determine the optimum tool angles and maximum feeds for the new materials in comparison with the older aluminum alloys and, to some extent, with the copper-base alloys used for screw machine parts. It would be possible to do this gradually over a considerable period of time during commercial production, but the time involved in such a procedure is apt to be great, and it seemed that the potential savings possible with the use of the new materials might justify the cost of determining some of the above factors in an experimental setup designed primarily for obtaining information rather than for the production of salable parts.

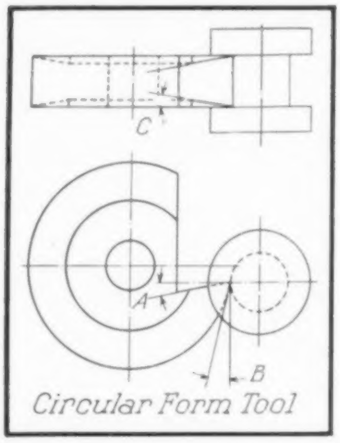
It was distinctly desirable to carry out such experiments on a standard automatic screw machine in a manner simulating production con-



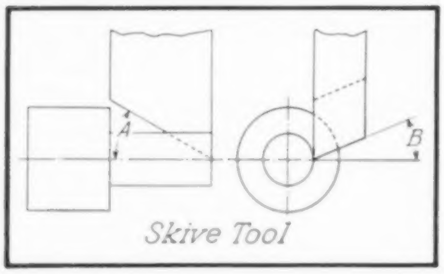
Twist Drill



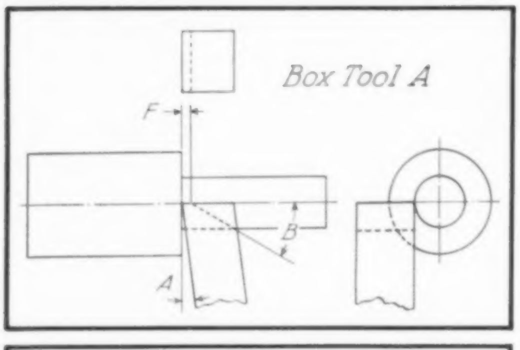
Straight Flute Drill



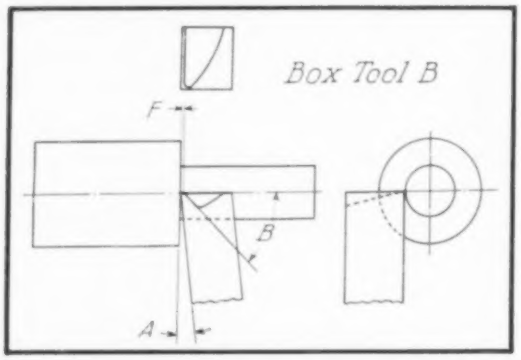
Circular Form Tool



Skive Tool



Box Tool A



Box Tool B

ditions as nearly as possible, and a No. 2 Brown & Sharpe single-spindle machine with a revolving turret was chosen for the investigation. The spindle speed is 3000 r.p.m. giving, with the ¾-in. stock utilized, a surface speed of 590 ft. per min. It was decided to determine the maximum feeds permissible with a number of variations in angles and design of four typical screw machine tools. Tools selected were two side-working tools, namely, skive and form tools, and two end-working, namely, drill and box tools. They were made of standard 18-4-1 high speed steel. One side-working and one end-working tool each were used in the same setup with each tool working separately. The combinations were as follows: (1) Skive and drill; (2) box and form; (3) form and drill.

The parts of arbitrary shapes chosen for production are shown in the half tone on page 35. Variations in tool angles investigated are listed in the table at the top left corner of this page. With each setup consisting of a certain combination of side-working and end-working tools of specific design, a definite small number of parts were produced at a specific feed from each of the materials being investigated. The feed was then increased by changing gears and another similar batch of parts produced from each of the materials.

The feed was thus increased in increments until the machine failed to function by throwing off the power belt

Dimensions of Tools

Optimum angles: *(17 S), △(11 S)

Tool	A	B	C	F
Drill, both	59°	14°	—	—
straight & twist	70	25	—	—
Circular form	-2	6	0.5°	—
	△0	△6	△0.5	—
	2	6	0.5	—
	△*4	△*6	△*0.5	—
	10	6	0.5	—
Skive	25	5	—	—
	25	15	—	—
	△*25	△*25	—	—
	25	30	—	—
Box, A	△8	△0	—	—
	8	10	—	1/32 in.
	8	37	—	1/32
	8	10	—	1/64
Box, B	△*8	△*45	—	△*0.010

Table I - Effect of Material on Maximum Feeds With Optimum Tool Shapes for Various Limiting Conditions

Tool	17 S		11 S		Brass	
	Feed	Relationship	Feed	Relationship	Feed	Relationship
Maximum Feed With Constant Power						
Drill	0.0475	100	0.070	165	0.070	165
Box	0.0525	100	0.064	122	0.064	122
Form	0.013	100	0.017	131	0.019	161
Satisfactory Surface						
Drill	0.0425	100	0.0425	100	—	—
Skive	0.010	100	0.013	130	—	—
Form	0.006	100	0.008	133	0.010	166
Box	0.020	100	0.020	100	0.0175	80
Satisfactory Dimensional Tolerances						
Drill	0.0425	100	0.0575	135	—	—
Box	0.0125	100	0.020	160	0.0175	140
Skive	0.019	100	0.021	110	—	—
Form	0.006	100	0.008	133	0.006	100

or by pushing the tools out of proper alignment. For each set of conditions, the parts produced, together with the chips, were carefully segregated, the volume of chips determined, and the parts carefully inspected for dimensions and surface finish.

Less Power Required

Some of the results are presented in Table I, where the maximum feeds are given for the best of the tool designs investigated. "Best tool design" was selected on the basis of the maximum feed for satisfactory surface and dimensions in two cases and, in the third, on the basis of maximum feed that would produce completed parts regardless of surface finish and dimensions. Admittedly the conditions do not duplicate those encountered in service, yet some significant deductions may be made. For example, the higher feeds possible without machine stoppage with brass and 11S than with 17S indicate that the power for cutting 11S and leaded brass under these conditions is about the same and decidedly less than required to cut 17S. It would also appear from these data that higher rates of tool feeding than are possible with 17S can be utilized in machining 11S and brass to satisfactory dimensional tolerances and surface finishes. These indications, having a very real bearing on the machine time required for producing a specific piece, should be reflected in definite economies in production.

Turning now to the question of bulk of chips, whether curly or fine particles, immediately below are quoted some figures giving the average volume of chips (cubic inches per piece) actually obtained with optimum tool angles for maximum feeds giving satisfactory surface and dimensions in the test piece.

	17S	11S	Brass
Skive and drill	11.6	3.8	--
Form and box	12.0	2.2	2.2
Form and drill*	6.2	4.3	2.5

Here it will be noted that the volume of the chips from 11S is about the same as that obtained from free-cutting brass and decidedly less than that obtained from 17S. This condition reflects a finely broken chip, illustrated clearly in the original article in Metal Progress, July 1935, and results in appreciable economies in the labor required for machine attention during operation and for separating parts from the chips.

Of the tool variations investigated, listed in the table on page 36, it is to be expected that certain tool designs would be more efficient than others. This proved to be the case, and the specific conditions giving the most advantageous tool designs for 11S and 17S, respectively, are indicated. The implication in the table that 11S may be machined satisfactorily with a wide variety of tool angles is again borne out in the following figures showing the versatility of 17S, 11S and brass, 17S being 100 in every case:

Maximum speed for jamming, grand average for all tools: 100 for 17S, 152 for 11S, 150 for brass.

Maximum feed for satisfactory surface, average for all tool variations: 100 for 17S, 123 for 11S, 104 for brass. Same for best tool shape for each material: 100 for 17S, 116 for 11S, 109 for brass.

Maximum feed for satisfactory dimensional tolerances, average for all tool variations: 100 for 17S, 223 for 11S, 138 for brass. Same for best tool shape for each material: 100 for 17S, 136 for 11S, 120 for brass.

Average maximum feed for optimum conditions, that is, satisfactory surface, dimensional tolerance, and best tool shape for each material: 100 for 17S, 139 for 11S, 106 for brass.

Average volume of chips from skive tool, all variations: 100 for 17S, 31 for 11S. Same for best tool shape for each material: 100 for 17S, 26 for 11S.

The above data indicate that the relative performance is not the same under all conditions investigated, but it is noteworthy that the *average* performance of 11S as compared with 17S, taking into consideration all the tool angles and conditions investigated, is appreciably higher than when only the optimum conditions are considered for each material. This indicates that 11S may be satisfactorily machined with a wider variety of tool angles than 17S.

The above sketchily described investigation yielded valuable data regarding optimum feeds and tool designs for cutting 11S. These short runs, however, gave no data regarding relative tool life and machine time efficiency. It perhaps was not inconsistent to expect that longer tool life would be obtained with the materials which would permit the higher ultimate rates of feeding. However, production runs lasting over a number of tool sharpenings were necessary to settle this point.

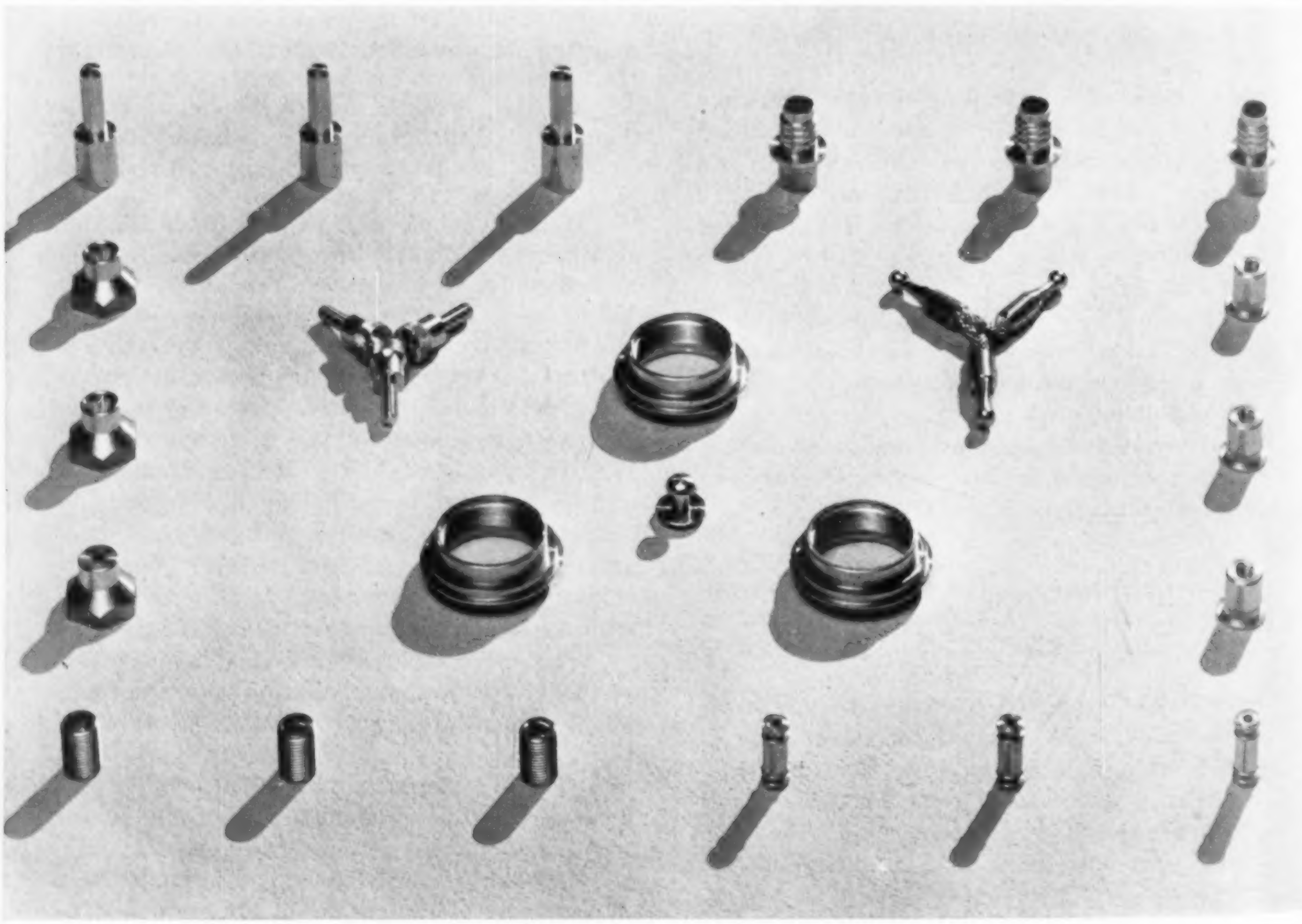
*The only combination investigated included a form tool with a −2° rake which gives about optimum results with brass but not with the aluminum alloys.

The difficulty of obtaining strictly comparable data in production is evident to anyone familiar with modern machine shop practice. Two different operators, for example, will obtain quite different results from the same material in ostensibly the same tool setup. Slight variations in machine conditions such, for example, as rate of oil flow, inappreciable changes in tool angles, variations in cutting characteristics of tool materials, will at times bring about relatively large differences in production during short runs. In view of these conditions, it is necessary to compare results over a considerable period of time. This necessity, of course, limits the number of jobs available for comparison, since frequently a minor change in the design between runs prevents a strict comparison.

A number of jobs have now been run in both 17S and 11S under conditions permitting at least an approximate comparison of the tool life with the new materials, and the production data regarding these runs have been collected in Table II. These are the results from long runs on relatively standardized parts, such as illustrated in the half tone. In general, these figures are more favorable to 17S than 11S, since the particular tool design utilized is the

Table II - Tool Life in Production
(Parts per Grind)

Part No.	Tool	Average Number of Parts		Per Cent of 17S
		17S	11S	
1	Facing	4,500	9,600	210
	Form	2,500	4,800	190
2	Tap	5,650	23,950	420
	Chamfer	9,000	9,000	100
	Cut-off	7,000	11,000	160
3	Forming	4,300	10,000	230
	Cross drill	4,000	8,000	200
4	Form grooves	700	3,000	430
	Cut-off	2,100	4,000	190
5	Forming	6,500	6,500	100
	Cross drill	6,500	13,000	200
6	Finish face	9,000	14,000	160
	Finish form	11,000	16,000	150



Representative Parts on Which Production Data Have Been Collected, 11S Vs. 17S

result of years of development in the machining of 17S and should, therefore, be nearer the optimum tool conditions for the economical production of parts from this material. As has been indicated in the foregoing, the optimum tool conditions for 11S will usually differ from those for 17S. Consequently, in making a change in production from the old to the new material, it is natural that the new material is not likely to have the benefit of optimum tool conditions. Nevertheless, it will be seen that the average number of parts produced between grinds is much greater with 11S; thus the average tool life of 11S should be, under the poorest conditions, at least as good as that of 17S and, under the most favorable conditions, should be four times that of tools cutting 17S. It is probably not too optimistic to expect the average tool life with 11S to be about twice as long as for the duralumin alloys (17S).

In Table III an attempt has been made to indicate the order of magnitude of the economies to be expected in machine running time with 11S as compared with 17S. In this table are given the rates of production per hour on Brown & Sharpe, Davenport, New Britain and National Acme machines, manufacturing parts illustrated in the group on page 38. It will be noted that the higher average rate of production with 11S is attained in three cases (No. 1, 10 and 11) by the use of higher speeds and feeds, but, in general, the higher production with the new material indicates only the economies attainable through less down-time for sharpening tools and clearing the machine from obstructing chips. The average saving in machine time by the use of 11S on these 15 jobs is about 20%, and it is to be expected that the utilization of optimum tool designs, speeds and feeds for 11S would show even greater economies than indicated in this table. This follows from the experiments showing that 11S may be machined at appreciably higher feeds than 17S. With one or two exceptions, the parts listed in Table III were produced in 11S using what might be described as "17S tooling."

Table III - Improved Machine Time Efficiency With 11 S

Part No.	Seconds per Piece	Average Production per Hr.		Minutes Saved per 1000 Pieces	Per Cent Machine Time Saved
		11 S	17 S		
1	(a)	530	460	17	13
2	4.3	679	577	15	15
3	4.8	575	250	137	56.5 (d)
4	3.0	855	790	6	8
5	4.2	679	625	8	8
6	1.6	1880	1550	6.5	17
7	3.0	1108	790	22	29
8	3.0	1033	790	18	24
9	5.0	565	460	24	18
10	(b)	1060	940	7	11
11	(c)	582	445	32	24
12	4.7	617	565	9	9
13	6.0	472	448	6	5
14	4.3	699	543	24	22
15	5.5	578	385	50	32
16	5.5	433	382	18	12

(a) 5.0 sec. for 17S-T; 5.5 sec. for 11S. 11S run on slower machine but with higher feed rates.

(b) 3.0 sec. for 17S-T; 2.6 sec. for 11S. 17S-T run on machine with shorter indexing time. On same machine, 11S production would be about 1400, saving 15 min. or 23.5%

(c) 6.7 sec. for 17S-T; 5.2 sec. for 11S.

(d) Much trouble with 17S chips and poor threads due to chips.

Optimum Tool Design Will Help

Another illustration of the economies resulting from lower requirements for machine attention when using free-cutting screw stock follows: A certain manufacturer uses in his product a considerable quantity of screw machine parts, some of which for years have been fabricated from duralumin or 17S. During the past year many of these parts have been changed to 11S. The manufacturer found on changing from the old to the new material that one man could satisfactorily attend to four machines instead of two machines as when cutting duralumin, thus cutting labor cost almost 50%. Total costs of the parts produced from aluminum alloys have been thus lowered 10 to 30% through the use of 11S. A part of this reduction in total cost is due in some instances to a small difference in cost of materials, but the major economies result from the saving in labor. Even here the maximum potential economies available in the use of 11S have not been generally attained, inasmuch as the new material is being produced with the same tooling as utilized with 17S. As experience with the new material accumulates, advantage will undoubtedly be taken of its ability to be machined with higher feeds when optimum tool designs are utilized. The working out of these factors, however, requires considerable time, but the economies eventually should be realized.

The earlier article (Metal Progress, July 1935) described two experimental alloys, each

of which was available in two tempers, W and T. One of these alloys (then designated XA11S) has been selected as possessing the best combination of properties for general application, and its designation has been changed to 11S. It is utilized principally in what is known as the "T3 temper." The mechanical properties typical of various sizes are given in the table below, as determined on standard tensile test pieces. This material is now available in a wide variety of standard sizes.

Table IV - Properties of 11S-T3

Size Range In.	Tensile Strength Psi.	Yield Strength Psi.	Elongation % in 2in.
0.125 to 1.0	51,800	45,800	15.0
1.0 to 1.5	48,900	42,100	14.0
1.5 to 2.0	44,100	35,600	19.0
2.0 to 3.0	41,200	29,500	22.0

It is, of course, obvious that the free-cutting alloy will not fulfill all requirements for aluminum screw machine parts. For example, service in a specific chemical environment may necessitate a copper-free alloy; under such conditions, an alloy of the magnesium-silicide type (51S or 53S) may be indicated. Under other conditions the mechanical requirements may be different from those of 11S; a higher strength material such as 17S may be indicated. Again an exact color match with other parts of an assembly may necessitate the use of an alloy less readily machined. Only time and the experience gained from service comparisons can finally determine the proper applications for this as for any new product. On the other hand, the new free-cutting alloy has already found application in forms other than screw machine stock. Forgings for a part requiring a great deal of machining are being produced commercially in 11S.

The new material will undoubtedly find its widest application in those parts, the machining cost of which is a relatively large proportion of the total. Even under these conditions, certain specific service requirements may frequently necessitate the use of materials not so economically machined. This suggests that before 11S is adopted for a new application, it be tried out to make sure that it meets the service requirements. The potential economies possible through its use are undoubtedly great enough to warrant its consideration wherever conditions permit.

SPECIAL STEELS FOR POWER PLANT

*Condensed from anonymous article "Research Into Special Steels," **The Engineer**, Oct. 30, 1936, p. 465*

UNCERTAINTY as to the reliability of metals under severe service is now the principal handicap to the development of more efficient power plants, in the opinion of a number of British engineers and industrialists. A great improvement had occurred in the last decade, as witness the following figures:

	1925	1935
Model practice; pressure	250 lb.	600 lb.
temperature	650° F.	800° F.
Best thermal efficiency	19.85%	28.59%
Lowest coal consumption	1.51 lb.	0.96 lb.
Average coal consumption	2.53 lb.	1.54 lb.

The engineer is desirous of going to still higher temperatures to avail himself of the superior thermodynamic properties of the heat cycle, the improvement in theoretical efficiency being 7 to 7.5% for every 100° F. increase in initial steam temperature above the first 800° F. So far, however, British constructors hesitate to match the American record of 1000° F. by the Detroit Edison Co.

Dr. W. H. Hatfield was of the opinion that data are now available for the limiting rate of creep for a given steel at a given temperature up to 1000° F. But the designing engineer wishes to know the safe limit of stress and the rate of deformation at such lower stress, and experiments to determine this require apparatus of such high precision that few have yet been constructed.

Other problems yet to be solved for the special steels were pointed out by representatives of the power interests: Accelerated intercrystalline cracking at high operating temperatures; influence of microstructure and the stability of such structures; influence of cycles of heating and cooling (intermittent service); corrosion by hot steam and by hot flue gases; short-time acceptance tests; assurance that laboratory properties will be duplicated in plant equipment. Acceptance tests that will guarantee the purchaser against sporadic heats of steel that do not act according to rule are also a pressing but a thorny problem.

Obviously most of these problems can only be solved by long-time experimentation or experience with operating units at and near the upper limit of temperature and pressure. A continuing research, supervised by the British Electrical and Allied Industries' Research Association, is under way, and the conference approved the desirability of increasing its annual budget to $15,000 per year.

Writing as metallurgist for Union Twist Drill Co. of Athol, Mass., Dr. Frazer calls attention to the fact that a "general purpose" toolsteel is essential if the manufacturer of cutting tools is to stock small tools suitable for service under an almost infinite variety of service conditions. 18-4-1, with improved mill practice and heat treatment, is still this general purpose toolsteel.

MODERN TOOLS OF HIGH SPEED

BY WILLIAM R. FRAZER

DEVELOPMENT of the modern cutting tool to its present efficiency is due largely to the interaction of two factors: *(a)* improvement in the design, material and heat treatment of cutting tools and *(b)* improvement in the design of machine tools.

The introduction of high speed steel into our machine shops early in this century required changes in drive shaft speeds, pulley ratios and gear ratios to take advantage of the increased cutting ability of the earliest improved tools. There were two factors, however, which limited the extent to which feeds and speeds could be increased — first, the vibration in machine tools lacking in rigidity and second, belt slippage.

Machine tool builders quickly appraised this situation and designed and built new machines capable of lower costs, so that older machines were made obsolete and industry was forced to buy new machine tool equipment. This improvement has been accelerated in the past few years. The new machine tools have been designed with care. Greater rigidity has been incorporated in the frame, bearings and spindles to minimize vibration, and by means of a positive driving mechanism, increased cutting feeds and speeds have been adopted which challenged the capacity of cutting tools to withstand this additional burden. It is quite evident, however, that the modern cutting tool has been fully capable of assuming these new responsibilities, when it is said that forged alloy steel blanks, Brinell 365 hard, are in mass production on machine lines.

This improved efficiency of metal cutting machinery has been closely related to the development of the material from which the tool is made and its heat treatment. The story of the development of air hardening steel by Mushet has been frequently told. It is worth repeating that American steel mills added chromium (an American ferro-alloy) to Mushet's steel to replace some of its manganese and to decrease its red shortness. Here was the source of the tungsten-chromium steel that Taylor and White experimented with when they found the high heat treatment which so vastly improved its cutting qualities. The late Dr. Mathews was responsible for the vanadium addition, and in 1906 our present type of tungsten-chromium-vanadium high speed steel was placed on the market. There have been modifications in its analysis, but when the average layman speaks of high speed steel, he refers to the 18% tungsten, 4% chromium, 1% vanadium type com-

Modern Screw Machine in Operation at Eastman Kodak Co., Using High Speed Tools on Free-Cutting Aluminum

monly known as 18-4-1. This steel has served industry well in all classes of tools and has been generally accepted as a standard tool material, its performance being used to judge the efficiency of other types of high speed steel which have been developed since its advent.

Considering standard high speed now readily available, we find several factors which have mutually aided in improving its cutting properties over the same types available one or two decades ago. They are

1. Chemistry
2. Mill practice
3. Hardening and tempering practice and heat treating equipment.

There has been a gradual change in the chemical composition in that the carbon content has been increased ten points to its present range of 0.65% to 0.75% and the vanadium content is now from 1.00 to 1.20% (approximately 0.20% higher than it was 15 years ago). There has been practically no change in tungsten and chromium content.

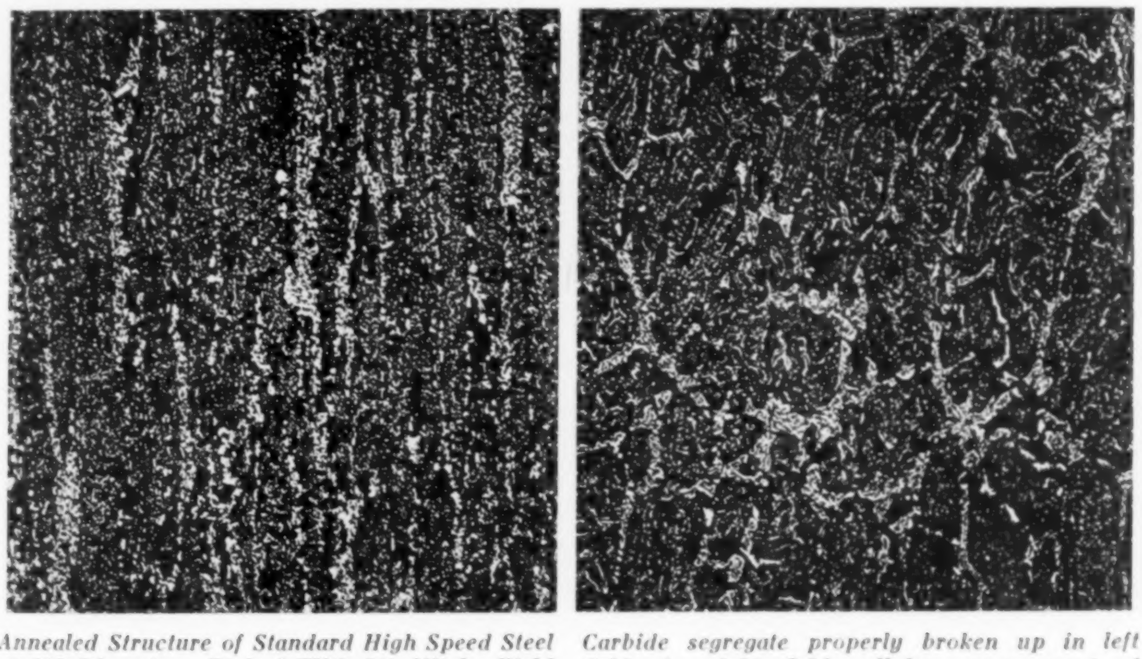
With the change in chemistry, we also find that the mills have found ways and means of improving their melting technique and mill practice so that our 1936 high speed steel shows a better structural refinement and is physically stronger to withstand impact loading. This improvement is the result of a very careful study by mill metallurgists as to the relationship between ingot size and design versus finished bar size. This hot work ratio and rolling mill technique exert a profound effect on the size and distribution of the excess carbides. The micros on page 43 show respectively the annealed structure of satisfactorily worked bars of high speed steel and an unsatisfactory structure due to the cellular arrangement of the carbides. (The photomicrographs are taken at half the radius from the periphery; similar ones could be shown for bars of smaller size.) A tool made from the bar shown in the right hand photograph would be extremely brittle, since the hard carbide envelopes are so arranged that they present continuous surfaces of weakness throughout the piece. The recent Campbell Memorial lecture by James P. Gill, abstracted in last

month's METAL PROGRESS, will give the reader some idea of the careful and detailed studies under way in the metallurgical departments of progressive toolsteel makers.

Simultaneous with this advance on the part of the steel makers there has been a decided improvement in hardening room equipment — hardening furnaces, tempering furnaces and temperature control instruments. The abovementioned change in chemistry has had its effect on the optimum heat treatment for toolsteel (1936 quality) in that the extremely high hardening temperatures required to obtain full hardness in the steels of 15 years ago are no longer needed. With the lower quenching temperatures used today, we obtain a finer grained, tougher steel with equal or higher Rockwell hardness, all of which tends to produce a better cutting tool. In the second pair of micros (page 44) is shown the structure of a properly hardened and tempered tool and that of an overheated and tempered tool. The latter consists of a coarse, acicular martensite which is inherently brittle. The samples used for these two photomicrographs are both Rockwell C-65 hard.

In view of the above remarks, it is apparent that high speed steel should be purchased on both chemical and physical specifications to insure uniformity of material; likewise that standardized heat treatments should be established for hardening the tools made therefrom. The result of putting this program into effect has produced better and more uniform tools for industry.

It is necessary for manufacturers of cutting tools to carry a large stock of standard sized tools in all types. These must give satisfactory service when machining any material under normal conditions encountered in customers' plants. This has required what might be called a "general purpose material" to produce a "general purpose tool," and it has been a blessing for the industry that standard high speed steel has been so generally satisfactory in meeting this condition. When specifying the heat treatment of these "general purpose tools," it is most practical to apply that treatment which will produce the toughest tool commensurate with the hardness required to cut the most difficult type of material. This has become particularly necessary during the past few years, since industry had adopted high alloy steels and alloy cast irons for the various parts which tools must machine at a high level of Brinell hardness. It is possible, moreover, to change the design of a tool, better to meet the requirements of a certain operation on a special material, and also to change the heat treatment of standard high speed steel to improve the performance of such a redesigned tool. It is likewise practical to use



Annealed Structure of Standard High Speed Steel at 100 Diameters, Etched With 5% Nital. Field located half way, edge to center on 6-in. round. Carbide segregate properly broken up in left field; in right field cellular arrangement of light etching segregate makes for brittleness

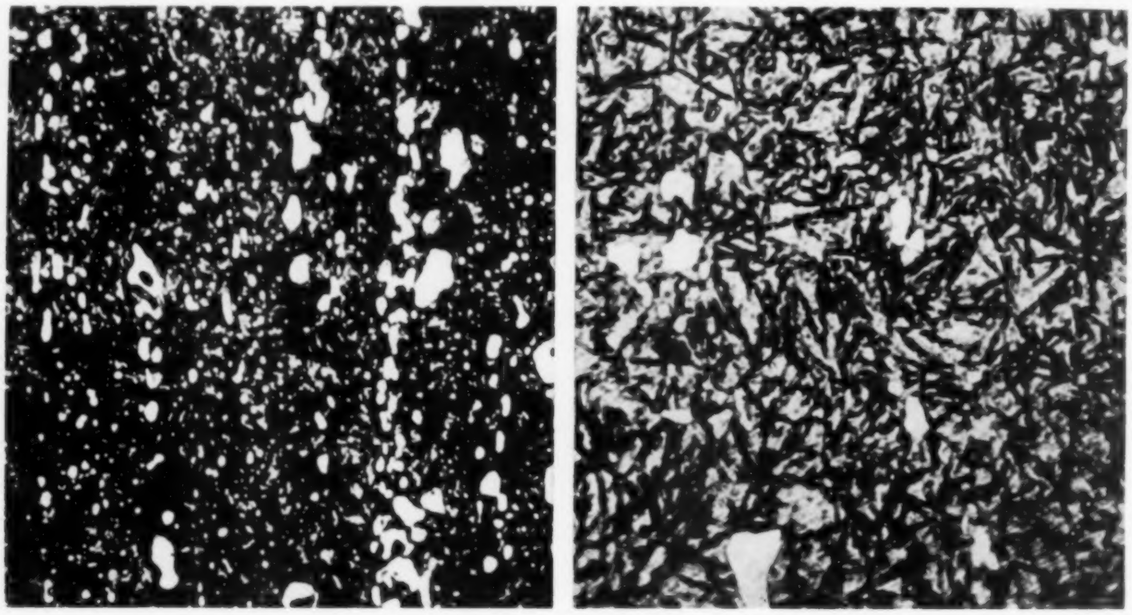
some of the special purpose steels which have been developed; such special tools are constantly being produced to meet the demands of progressive customers.

During the past 20 years, the toolsteel industry has developed and marketed certain so-called "super high speed steels" which we would prefer to call "special purpose high speed steels," as none of them have superseded 18-4-1 as an all purpose steel.

The promotion and use of these special purpose steels is accomplished in three ways:

1. Tests by the steel producer.
2. Tests by the tool manufacturer.
3. Advertising.

It is general practice for the steel producer to conduct a lathe tool cutting test for determining the cutting efficiency of any toolsteel he is studying. This test has been adopted because it is used by one of the U. S. Government departments in testing and calibrating the cutting efficiency of various brands of high speed steel. It will tell something about the red hardness, toughness under steady load and wear resistance of the steel, but little about its resistance to impact loading or torsional strength. Consequently, it is necessary for the tool manufacturer to conduct accurately controlled heat treatments and actual tool tests before he can decide on the specific merits and suitable application of the steel in question. This is one of the interesting and important phases of the metallurgy of tool manufacturing. Often the steel producer will advertise his special steel, making claims which will attract the attention of industry to the extent that customers will order certain tools made from the new steel for experimental purposes. By following the performance record of these tools, the tool manufacturer obtains much valuable information regarding the success of the steel under definite operating conditions.



18-4-1 High Speed Steel (1936 Variety); Left: Properly Hardened and Tempered for Toughness; Right: Improperly Hardened and Lacking in Toughness. Hardness of both samples, Rockwell C-65. Etched in 5% nital, magnified 1000 diameters

Some of these steels might be classified in accordance with chemical analysis as follows:

Steel	C	W	Cr	V	Mo	Co
A	0.70 to 0.85	18.0	4.0	2.0	0.5	—
B	0.70 to 0.85	1.5	3.75	1.1	9.0	—
C	0.70 to 0.85	14.0	4.0	2.0	—	5.0
D	0.70 to 0.85	18.0	4.0	2.0	0.5	7.5
E	0.70 to 0.85	19.0	4.0	2.0	0.5	12.0

Steel A possesses greater hardenability than standard high speed, maintains a very keen cutting edge and is wear and abrasion resistant. However, it is inherently more brittle than 18-4-1 and therefore finds its best place in finishing tools where light cuts are taken. It is also satisfactory for machining abrasive materials such as cast iron, aluminum, copper and its alloys.

Steel B is a molybdenum steel which has been developed during the past few years as one which exhibits greater toughness with like hardness or greater hardness with like toughness of 18-4-1. (See METAL PROGRESS, June 1935.) It is a cheaper steel than 18-4-1 and has been used quite extensively in tools where excessive red hardness is not required but toughness is a considerable factor.

Steels C, D and E are the cobalt high speed steels, and all possess much the same properties in that they show greater red hardness, wear resistance and cutting ability on heavy cuts than the other types. Their greatest drawback is brittleness, which causes failure either by chipping at the cutting edge or complete breakage of the tool. They are not satisfactory for interrupted cutting or for hobbing or milling where the tool must withstand impact. For heavy duty turning, however, they appear to be satisfactory. Their efficiency (and cost) increases with the tungsten and cobalt content.

Undoubtedly, as we learn more concerning the fabrication and treatment of these special purpose steels, we will find more applications for them, but at the present time it is the firm belief of the writer that standard 18-4-1 type of high speed steel is still the best all purpose steel. Its present improved state of development is due to closer control of chemical and physical requirements in the bar stock and improved hardening and tempering technique in the tool room.

MEASURING TEMPERATURE OF LIQUID STEEL

Condensed from Second Report, Steel Castings Research Committee, British Iron & Steel Institute, 1936

IT IS AGREED that the calibration is most important, and should consist of checking the optical pyrometer very frequently and at the temperature of use; extrapolation from some relatively low temperature should not be relied upon. The comparison standard may be a previously standardized optical pyrometer, or rare-metal thermocouple, checked at a known high fixed point, such as the freezing point of nickel. The hot body sighted upon should have the characteristics of the hypothetical black body. Since a platinum thermocouple does not remain constant at 2800° F., it should be checked before and after use. A calibrated tungsten strip filament lamp may be used as an alternative source of high temperature.

There is usually close agreement between various observers so long as they are fairly well accustomed to the optical pyrometer being used. There is undoubtedly a tendency for differences between various observers, which is not constant from time to time, and which has also been shown to vary according to the specific instrument used.

One should not be satisfied with a greater disagreement among laboratory observers than ±5° F. Greater variation than this, even among the various readings obtained by a single observer, probably is due to eye fatigue or lack of ideal conditions.

Several tests have been carried out in which a number of disappearing-filament pyrometers have been compared with one another under industrial conditions. Sometimes the agreement was good, but on several occasions the tests showed great discrepancies between the readings given by various observers.

Variations are no doubt influenced by the choice of red screen and neutral screen, but it is now possible to fit glasses to disappearing-filament pyrometers which comply with the theoretical conditions required.

In an individual works, using one reliable instrument continually, experienced observers can, under good conditions, attain a degree of accuracy of repetition in their observed temperatures of ±9° F. (± 5° C.), and under such conditions the measurements are of considerable value to the steelmaker. The apparent temperature of a steel is, of course, affected by its emissivity, which largely depends upon the condition of its surface.

The following recommendations are made:

1. Great care should be taken with the initial calibration of the instrument.

2. The stream observed should be free from fumes.

3. The observed surface should be "smooth," that is, the stream should not be straggly or contain folds.

4. The operator should always sight on the stream in, as nearly as possible, an identical position from one time to another. The positions recommended are: **(a)** In tapping, where the stream leaves the launder, viewing normally from the windward side. **(b)** In casting, as close to the nozzle as possible, also viewing normally from the windward side.

5. Under these conditions, an emissivity factor of 0.40 may be selected as reasonably correct for ordinary steels. Where reference to absolute temperature scale is desired, a correction corresponding to this value should be applied to observed readings.

6. The instrument cover glass should be cleaned before each set of readings.

Edgar Collins Bain

PRESIDENT, AMERICAN SOCIETY FOR METALS

SHORT HILLS, N. J., is a remarkable community. Of its 355 men, women and children, 20 men and one woman are in *Who's Who in America*. Of those 21, eight are scientists. Of those eight, three are in the metallurgical field.

Those three scholarly scientists are high executives of the United States Steel Corporation — Rufus Eicher Zimmerman, vice-president; John Johnston, director of research; Edgar Collins Bain, assistant to Vice-President Zimmerman. Youngest of the three and youngest of all the Short Hills notables except one, is Metallurgist Bain, 45, president elect of the American Society for Metals, whom Lehigh University made a doctor of engineering last graduation.

The Bains (Mrs. Bain was Helen Louise Cram of Cleveland) were married in 1927, have a daughter Alice Anne, 8, named after Mr. Bain's mother, and a son David, 4.

The Bain home often harbors some sort of photographic laboratory since photography is intermittently Dr. Bain's hobby. He contrived to accomplish high speed photography many years ago and even dabbled in the early methods of color photography. Dr. Bain would like to have a larger workshop and covets a rambling barn wherein he and his son may sometimes tinker together. Deeply affected by his own boyhood on a farm near Marion, Ohio, he wishes every boy might have a barn.

Dr. Bain's office is on the 19th floor of the Empire Building, at 71 Broadway, New York City. His window looks northwards over the cemetery of Trinity Church. He habitually sits with his back to that window facing visitors over a broad desk bearing a few stacks of papers and normally a steel section or two and a few fractured test pieces.

Dr. Bain is a short, stocky, sandy-haired man who talks softly, quickly and to the point. After a conference visitors leave informed and thoughtful.

As a student, at Ohio State, Wisconsin and Columbia, Dr. Bain was not a consistent scholar. On the contrary he did meritorious work in some courses and mediocre work in others. His favorite courses were in industrial chemistry and physical chemistry. Perhaps the urge to work with metals existed early, for he remembers with stirring vividness his first look at a photomicrograph of steel shown by the late Professor Nathaniel Wright Lord and his own wish to try such investigations. He was elected to membership in the honorary fraternities Phi Lambda Upsilon (chemistry) and Sigma Xi (scientific research). He holds the following degrees: B. Sc. in Chem. Eng., M. Sc., Ph. D., and Dr. Eng.

As a scientist Dr. Bain first contributed to the knowledge of the transformation (allotropy) of iron and steel by determining the atomic structures by means of X-ray diffraction. At the same time he examined solid solutions and found some inconsistencies in the existing diagrams of supposed homogeneous solid solution binaries. He proposed, with his co-workers, acceptable hypotheses on the behaviors of a number of alloy steels and particularly of high speed steel. He is co-author with Dr. M. A. Grossmann of a small book on this subject.

He later became absorbed in the study of the whole family of chromium and stainless steels and for several years contributed to improvements in these valuable materials and clarified some of their unusual habits. The family of iron - carbon - manganese steels was explored under his direction both as to equilibrium and as to rate of reaction. Perhaps the most useful study by Dr. Bain was that of the rates of transformation of various steels at a variety of temperatures. This study cast most welcome light upon the hardening of steel and made quite simple most of its complexities. Out of this research an improved method of heat treatment was evolved. In these problems Dr. Bain was aided by brilliant associates to whom he ascribes much of the credit for their solution. Their names are found frequently with his as co-authors of some forty technical papers.

Dr. Bain's progress through American industry has been with the greatest examples in the land — chemical engineer with B. F. Goodrich Co. (1917); metallurgist with National Lamp Co. (1918-22); research metallurgist with

Atlas Steel Co. (1922-24); Union Carbide & Carbon Research Laboratories (1924-28); United States Steel Corporation (since 1928). Last year he became assistant to Vice-President R. E. Zimmerman.

In preparing for this biographical sketch of President Edgar Collins Bain of the American Society for Metals, METAL PROGRESS asked some of his co-workers for notes. The response was remarkable, reflecting the progress of this man in the hearts and esteem of his colleagues. Herewith are informative, warrantably l e n g t h y extracts of those comments:

Bain at National Lamp: "Ed came to the Cleveland Wire Works fresh from the Chemical Warfare service and still in uniform [of a First Lieutenant]. We were then operating in cramped quarters and Ed shared an office with one or two of the older inmates. One of his first endeavors had to do with photographing the 'burning out' of filaments in lamps. For this he made his own equipment in a temporary dark room and obtained some valuable pictures. His previous knowledge of photography aided him in this.

"About this time radio was becoming popular and Ed devoted considerable time to studying the filament characteristics of the tubes which General Electric was then producing. His experimental receiving set was a source of great interest to all of us and also a bone of contention, since he had trouble at times in isolating it for his experiments.

"His real work, however, began with the growing interest in X-ray diffraction methods of crystal analysis as applied to metals and alloys. Ed assembled some apparatus for this purpose which is still in use at the Wire Works laboratory. For two or three years he used to spend many nights upon this work and in consequence was often absent-minded and irritable during the daytime. Herbert Tareyton cigarettes (which he called Herbertons) appeared to sustain him in these vigils!"

Bain at Atlas Steel: "I remember very well my first letter from him in reply to one I had written to him after seeing one of his articles in *Chemical & Metallurgical Engineering.* I made some comments on some topic now forgotten, and remember his assuring me that I was quite right, and my wondering how he, who was not in the steel business, could tell me about it when I had already been working for a steel company for a whole year! This began a correspondence which became a closer association when we both worked for the Atlas Steel Corp.

"At Atlas, the one incident or series of incidents which both he and I refer to most frequently was how we used to meet at night at the laboratory and break specimens on our homemade impact machine. The number of specimens must have run into the thousands. Other recollections include our competition in making dilatometer measurements, my admiration of his ingenuity in getting a piece of high speed steel cooled very slowly from the melt by taking a piece of ladle skull, our frequent heated arguments on metallurgical matters, his extraordinary facility in making telling comparisons. ('I ask you for an automobile and you give me a toothbrush.') Our metallurgical slogan was 'Let's run a series,' for we often deplored the fact that all available data seemed to be individual observations."

Bain at Union Carbide & Carbon: "Ed Bain was the acknowledged 'spark plug' and leader of the steel research group. Among his outstanding achievements from the standpoint of his coworkers are the appreciation and study of the delta phase in the high chromium steels, and his comprehension and experimental establishment of the relationship of chromium and carbon in these steels. In the course of this work he originated the 'universal' micro-specimen. This is produced by melting with an oxyacetylene torch one end of a very short, rectangular specimen while holding the other end in water and then quenching the whole.

"Ed envisaged and worked out the chromium-iron-nickel system. In this work, as well as in the previous work on chromium - iron, he intelligently combined the X-ray with the results of microscopic investigations and indications of other laboratory tools. In connection with his X-ray work he also did some remarkable radiography, particularly on brass castings of complicated shape. Toward the end of his stay with us, he initiated work on the decomposition of austenite at liquid air temperatures, and also started an investigation of the transformation change at black heat. In this connection, he made the first dial type dilatometer for measuring the change in length of steel while undergoing transformation. This latter work furnished the starting point for his subsequent, now famous work on transformations in steel.

"I well remember Ed's uncontrolled glee when a specimen of medium manganese steel quenched in oil and withdrawn while still hot

failed to respond to a magnet immediately after quenching but became magnetic in a short time, as well as his keen delight on the first appearance of the X-ray spectra lines corresponding to the brittle compound in the iron-chromium-nickel system.

"Ed always liked to discuss the theory of steels and the philosophy of metals, and in these discussions he never failed to bring out some new point of view or otherwise stimulate his co-discussers. As a result of discussions of the above type, in 1926 it was concluded that the structural and engineering steels presented the most potentially fruitful field for metallurgical investigation. His subsequent work on transformations was a direct follow-up of this point of view.

"He has a vast fund of knowledge on subjects unrelated to metallurgy, as well as a real appreciation of the arts. He has a fund of good stories and analogies, and is the best raconteur of dialect stories I ever heard.

"All who knew him at Carbide agree that he would have been a success in any field into which he ventured because of the peculiar combination of sensitive but controlled emotions, a soaring but controlled imagination, and one of the most logical minds it has ever been our pleasure to encounter. He was ever willing to discuss other people's problems with them and his advice on general as well as technical matters was invariably sound. He was admired and respected by all of us, and generally accepted as a charming companion and good fellow."

Bain at U. S. Steel: "If there is any one feature which has characterized E. C. Bain's career since he joined the staff of the United States Steel Corporation Research Laboratory, it is the large number of well-deserved scientific and technical honors and distinctions which have come to him in that period. His record of achievement in this respect is unique since it is a recognized fact that no other single individual, at least in the metallurgical field, has ever succeeded in accumulating an array of medals, awards, and lectureships comparable to that of Bain's.

"In 1929 Bain was awarded the Robert W. Hunt Medal of the American Institute of Mining and Metallurgical Engineers for his paper (with W. E. Griffiths) on 'An Introduction to the Iron-Chromium-Nickel Alloys'; in 1931 he received, jointly with K. Heindlhofer, the Henry Marion Howe Medal of the American Society for Steel Treating for a paper on 'A Study of the Grain Structure of Martensite'; in 1935 he was awarded the American Iron & Steel Institute Medal for his paper on 'Some Characteristics Common to Carbon and Alloy Steels.' He was selected by the Iron & Steel Division, A.I.M.E., to deliver the Henry Marion Howe Memorial Lecture in February 1932, which contribution was entitled 'On the Rates of Reactions in Solid Steel'; he was chosen to deliver in the same year the Edward DeMille Campbell Memorial Lecture of the A.S.S.T., which lecture was entitled 'Factors Affecting the Inherent Hardenability of Steel.'

"Appointed by Dr. John Johnston in 1928 as one of the first members of the staff of the newly formed United States Steel Corporation Research Laboratory, Bain had a large part in the organization and development of the Kearny laboratory to its present status. He was placed in charge of the metallurgical work of the laboratory and his contributions to metallurgical knowledge from that source since 1928 have ranged over the whole field of ferrous metallurgy, covering such subjects as stainless steel, heat treatment, grain size, hardenability, low alloy steels, transformation rates, and many others. His generalizations in these various fields have thrown new light on many obscure metallurgical phenomena and our present understanding of the hardening of steel has been greatly clarified by the originality and soundness of his contributions.

"His broad grasp of fundamental metallurgical principles together with his engaging personality and tireless energy and enthusiasm have constituted a source of inspiration to his fellow-workers and have been instrumental in bringing out the best that was in them. His rare ability to speak and to write clearly on involved technical subjects is well known to technical audiences and readers throughout the world; there is no doubt that this ability is, in no small measure, responsible for much of his success in his chosen field.

"As the Kearny laboratory grew and developed, Bain's responsibilities and activities increased and much of his time was devoted to the development of contacts with and for the subsidiary manufacturing companies of the Corporation. In this field he was again eminently successful, both in making friends and in sensing the important metallurgical trends of the time. He has been sent on two trips abroad in connection with his work, once in 1932 and again in 1935."

The sad news must be chronicled of the death in Liverpool, England, of F. Grimshaw Martin, whose letters and articles concerning the use of metals and welding in shipbuilding have appeared frequently in METAL PROGRESS. *Mr. Martin was only 58 years old. Prior to 1916 he was chief science master of the Liverpool Collegiate School; at that time he organized the testing laboratories of Alfred Holt & Co. His most important metallurgical work was on the heat treatment of mild steel ship plate; this variety became known as "Martinel" and large tonnages have been produced under his direction and used in recent British ships, including the Queen Mary. He took an active part in civic affairs.*

LETTERS FROM HOME AND ABROAD

Definition and Classification of Inclusions

PARIS, *France* — In company with René Castro, the undersigned has contributed a series of papers to the British Iron & Steel Institute on the "Morphology of the Inclusions in Siderurgical Products." More than once in the preliminary studies the authors have attempted to formulate a definition of the term "inclusion." (For instance, is a nitride an "inclusion" in the high chromium steels?) The following is therefore an attempt to outline briefly what is generally understood by the term, and to lend it some degree of precision.

The expression "inclusion" denotes a substance foreign to the essential constitution of the alloy and generally harmful, thus indicating at least partial insolubility in the metal and the idea of impurity. The expression "sonim" originated by Hibbard is derived from solid (so), non-metallic (n), and impurity (im). Primarily, inclusions may be classified as nonmetallic and slag inclusions, both terms being sufficiently descriptive. Chemically they are subdivided according to their principal constituents, thus: Silicates, oxides, sulphides, nitrides and carbides. Whether or not a chemical compound or complex of the above chemical types is or is not an "inclusion" depends upon its properties:

1. Its insolubility in the metal, either liquid or solid.

2. Conversely, its solubility in ordinary siliceous slags.

3. Its non-metallic character, as indicated by its conductivity, opacity, brilliance, and atomic bonds.

4. Its harmful character, in the sense of an impurity.

These characteristics are somewhat interrelated. Thus the metallic character agrees in general with solubility in metals and insolubility in siliceous slags, while non-metallic elements are often harmful to the ordinary properties of steel and other alloys. However, such distinctions, although they seem clear enough on rapid and superficial examination, become much less simple after a little more detailed investigation.

We will now briefly consider the chemical classes noted above.

1. *Silicates.* These include aluminates and silico-aluminates and represent the most typical non-metallic inclusions, being nearly insoluble in metals both liquid and solid, and having the

same ionic character as aluminates. For this reason we will take this type as a standard of comparison for the other constituents. (It should be mentioned that we have observed precipitated inclusions in chromium steel in the form of eutectiform dendrites, which indicates solubility in liquid metal.)

2. *Oxides.* Although the basic oxides Na_2O, CaO and MgO are ionic compounds and the acid oxides SiO_2 and Al_2O_3 are considered by some as covalent and by others as partly ionic, a slight metallic character begins to appear in certain of the basic oxides. Oxides of iron, nickel and cobalt are slightly soluble in the corresponding molten metal, while Cu_2O is soluble in molten copper up to nearly 10%. Manganese, intermediate between iron and calcium in the periodic table, is ionic in its atomic linkages, and our observations indicate the partial solubility of oxides of the (Fe, Mn)O type in liquid iron and the relative transparency of MnO. Although there is a break in liquid miscibility between silica and various basic oxides, it must be noted that magnetite, chromite, and the spinels are only slightly soluble in slags unless they are very basic.

In general, oxides and silicates are always regarded as harmful impurities, without, however, any good arguments or data to support this opinion.

3. *Sulphides.* Although certain sulphides are definitely ionic compounds (aluminum sulphide) and only slightly colored (zinc sulphide) the metallic character appears in the sulphides of denser metals. Sulphides of iron and of manganese are soluble in iron and at the same time partly soluble in basic siliceous slags; sulphides of nickel and cobalt are entirely miscible with their molten metals and practically insoluble in their slags — they have a metallic brilliancy and conductivity.

As we mentioned in the course of our study, oxides and sulphides are frequently associated and produce inclusions with mixed eutectics, implying liquid miscibility; they both can be decomposed by heating at high temperature. Their aspect and color border on those of the carbides.

Although sulphides, like oxides, are generally considered as impurities, in certain types of soft steel they are used to facilitate cutting operations.

4. *Nitrides and Carbides.* Although the alkaline carbides are ionic compounds — attention might be called to the *(Continued on page 86)*

Electric Furnace Iron for Castings

TURIN, *Italy* — The use of electric furnaces for the manufacture of pig iron and cast iron has been greatly developed in Europe during the last few years, but has followed different lines in the various countries due to the various economic and industrial conditions prevailing.

The four typical lines followed by this development may be briefly stated, thus:

1. Reduction of iron ore by carbon. This process is at present used in a normal industrial scale in Sweden and Italy, where hydro-electric power is abundant and cheap. In Sweden, where plenty of good charcoal is available at low prices, electric furnaces of the blast furnace type manufacture a high grade pig iron from the very pure domestic ore. In Italy the same type of furnace is used only in a few cases where iron ores of a great purity, similar to the best Swedish ores, are available. In all other cases, a poorer quality of ore must be used, the pig iron must compete with the product of regular blast furnaces, and the use of charcoal is therefore impossible. In these instances the Swedish type of furnace has given unsatisfactory results, and has been satisfactorily replaced with others of a new design, as noted in my letter last month.

2. Melting of low grade iron scrap, mixed with various amounts of iron ore, coal, manganese ore and silica, usually in open top electric furnaces of the shaft type generally used for ferro-alloys. This "mixed process" is used in several European countries, but only where a large supply of low grade iron scrap is available. This is therefore to be considered rather as a means of utilizing exceptionally large quantities of a local byproduct, than as a normal industrial process. Practically all known types of electric furnaces have been used for this process at some time or another; the Miguet furnace has given excellent results. The applications of the process are practically limited to the production of foundry iron.

3. Melting of low grade iron scrap in electric furnaces of a design similar to that of the Heroult steel furnace. In this case — where the electric furnace replaces the cupola or the revolving furnace — the contingent advantages of the process depend strictly on local conditions. Under those peculiar to Italy the electric furnace is more economical than the cupola even in very small foundries, making less than 50 tons of castings per month. *(Continued on page 88)*

Reasons Why Flakes Seek an Intermediate Zone

MILAN, *Italy* — A paper by Mr. Reggiori and myself on the cause of flakes in forgings, printed in the July issue of METAL PROGRESS, quoted the recent theory of German workers that these defects are due to the liberation of hydrogen during cooling in a narrow interval of temperature, namely, 400 to 600° F. We were able to produce flakes in samples of sound steel by heating them in a hydrogen atmosphere and cooling them fairly rapidly through the above-mentioned range.

One criticism of this theory has arrived which is worth discussion. It would seem to the critics that the deepest strata would be the most suitable for flakes because it is hardest for the hydrogen to diffuse outward with sufficient rapidity during anything but a very, very slow cooling. Why then, they ask, should not the exact central portion of a large piece of steel be the most likely locus of flakes rather than the region mid-way between the center and edge, as is most frequently noted?

The hypothesis that flakes are produced by hydrogen seems to us sufficiently proved by our experiments, yet it does not necessarily imply that flakes must be formed in the region where hydrogen has its maximum concentration — even if it will be admitted that this maximum is reached in the central region, a point that could be discussed.

For instance, the fact that the flakes are less frequent in the center can be explained by the observation that the very center is often porous, especially in big forged pieces, and consequently the hydrogen which gets free can expand without reaching pressures high enough to crack the metal. Several observations made by us on blooms of chromium-nickel-molybdenum steel seem to confirm this point of view.

Another explanation can be the following: When a piece of steel is cooling, a gradient of temperature is formed between center and periphery which depends on the conditions of the cooling. As long as the temperature is high enough, hydrogen, owing to its great diffusivity and mobility, can migrate from points of higher toward lower concentration, and also escape from the steel if the saturation point at the surface layers is reached.

Sooner or later a temperature is reached where there is the sudden drop of the speed of diffusion (observed by Jaquerod and Gagnebin to be between 350 and 575° F.) in a certain zone which will not be the periphery, but also not always the center, and this zone will originate the optimum conditions for the formation of flakes. As soon as the first cracks are formed, these become paths of escape for the hydrogen from deeper seated metal.

It could also be thought that dendritic segregation, thermal stresses and the other causes blamed for the formation of flakes can sometimes help determine the position and the orientation of flakes, because these will form more easily in those parts which have the least resistance; thus, the correlation many times observed between dendritic segregation, nonmetallic inclusions, cooling stresses and flakes.

Typical examples of these more-or-less casual correlations can be found in the illustrations in our article last July. Furthermore, our experience shows that flakes have a preferred radial orientation in the cylindrical pieces heated in hydrogen and quenched, and are located very close to the surface, while in those cooled more slowly (in the air) the flakes do not have any preferred orientation and are found in the center of the piece.

Indeed, in the first case the quick cooling more or less completely prevented the hydrogen from migrating and distributing itself evenly throughout the metal, and the pressure produced by this gas can thus reach its maximum in a certain zone. To this pressure will be added the cooling and quenching stresses. (These latter will be particularly dangerous because the formation of martensite happens to be in the same temperature range at which there is the sudden drop of the diffusivity of hydrogen.) These different causes explain very well the formation of flakes near the surface and with a radial orientation, such as we have observed in all quenched pieces.

It must also be remembered that our experiments have been made by heating pieces of steel in a stream of hydrogen; the resulting gas concentration will then be higher near the outside surface and decrease toward the center of the piece — at least as long as the saturation point corresponding to the experimental conditions is not reached. Hence when a piece unsaturated with hydrogen is quickly cooled, flakes will have greater chance to form in a region near the surface than at the center. Our experiments seem to be in accord with this point of view, because in all quenched cylinders flakes have generally been found close to the periphery in mid-length

regions, and usually throughout the entire cross-section in the regions near the bases, thus favoring those surfaces through which hydrogen gained access to the metal.

In the case of slowly cooled pieces, the diffusion and elimination of hydrogen can proceed more or less completely, and the stresses are much smaller; therefore the flakes do not have any preferred orientation or location, but are distributed at random.

Finally, if the speed of cooling is so low that hydrogen has sufficient time to distribute itself evenly in the metal and to escape from it, the local pressure of hydrogen can be so small as to be insufficient for the production of flakes.

It can thus be concluded that the orientation, the position and the shape of flakes is dependent not only on the kind of material tested, but also on the conditions of the test; but it seems to us sufficiently proved by our experiments that the presence of hydrogen in the metal is the *determining cause* of their formation.

I. Musatti
A. Reggiori

Hardness of Thin Sheet

New York, N.Y. — In the September issue of Metal Progress appeared an excellent article entitled "Sheet Metal Appraised by Hardness, Ductility and Grain Size" in which it was said that the problem of obtaining the correct hardness of thin sheet is not yet solved, but no reference was made to the contribution of the Rockwell Superficial Hardness Tester to this problem. This uses much lighter loads than the regular Rockwell, and is being used with much success for testing sheet metal too thin to be accurately tested on the regular Rockwell, even though there still remains metal too thin for it. The article tabulates the limiting thickness of sheets on which Rockwell B scale readings can be made without a deviation of two numbers. These values are taken from Fig. 4 in R. L. Kenyon's paper entitled "Effect of Thickness on the Accuracy of Rockwell Hardness Tests on Thin Sheet," presented at the June 1934 meeting of the American Society for Testing Materials. They are for polished surfaces, as Mr. Kenyon

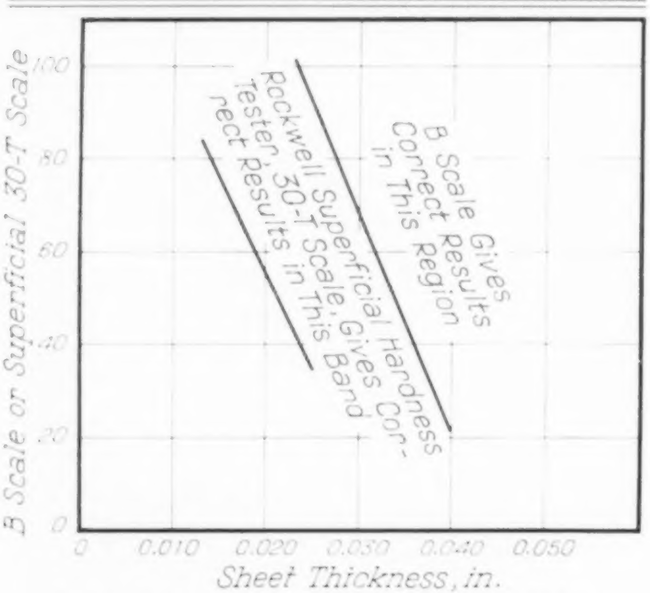
K N O W   Y O U R   I N D U S T R Y

Photo Courtesy H. H. Harris

Enlarged Airviews of This Plant Will Be Given to the First Six Who Identify it Correctly

found that the values vary considerably with the surface condition of the metal being tested.

Mr. Kenyon plotted the thickness of sheet being tested against depth of impression rather than against the B scale of the regular Rockwell, and his work included tests made with the F scale ($\frac{1}{16}$-in. ball penetrator and 60-kg. load) and likewise with the Superficial Tester using loads of 15, 30 and 45 kg. In the attached graph the values for sheet thickness against B scale hardness values are shown ($\frac{1}{16}$-in. ball penetrator and 100-kg. load), and likewise the thicknesses of material which can be tested on



Limiting Relation Between Hardness and Thickness of Sheet Metal to Avoid Erroneous Results. Plotted from data secured by Reid L. Kenyon

the 30-T scale (30-kg. load and $\frac{1}{16}$-in. ball penetrator) of the Superficial Tester. This brings out clearly that much thinner material can be tested on the latter than on the regular Rockwell, which represents a big advance in the field of testing sheet metal. The same equipment can be used for even thinner material by using the 15-T scale, although the sensitivity of the machine would be reduced.

In discussing the occasional practice of testing a pile of two or more sheets, the article in Metal Progress states that this fact should be reported for whatever interpretation the reader cares to make. This practice should be discouraged with all the means at hand. In the Tentative Methods of Rockwell Hardness Testing of Metallic Material, A.S.T.M. designation E 23 — 34 T, under the section entitled "Test Specimens," it is stated that "All Rockwell hardness tests shall be made on a single thickness of the material, regardless of thickness," and refers to a footnote reading as follows:

"The requirement is essential because experience has shown that tests made on more than one thickness are unreliable. The use of more than one thickness is only resorted to, as a rule, in the case of material which is so thin that the impression made on a single thickness will show through on the under side. The use of additional thicknesses of the same material under the 'test piece' does not give at all the same effect as a solid piece of the same thickness as the combined pieces. Flow takes place on the surfaces between the various pieces and the amount of this varies with the condition of these surfaces. Another large source of error is due to the lack of flatness of the separate pieces which leads to a compression of the pile under the major load. This is partly elastic and partly permanent set and introduces an unknown factor into the test."

May I add that I am not making a mere suggestion that the Rockwell Superficial Hardness Tester *could* be used for accurate testing of much thinner sheet than can be tested on the regular Rockwell, but rather reporting that it *is* so being used by many mills rolling sheet metal, ferrous and non-ferrous, and by many important plants specifying in terms of the Rockwell Superficial Test in purchasing thin metal from the mills. V. E. Lysaght.

Precision Machining

Schweinfurt, *Germany* — An important factor in the development of machines and tools, as well as fabrication processes, is the ever-increasing demand for precision working and its economies.

This had induced the Committee for Economic Production of the German National Department of Economics to form a technical committee from various branches of the industry to clarify the problem of precision working and make the information more widely accessible. A paper by Carl Büttner in *Zeitschrift für Metallkunde*, April 1936, gives some of the results; the following notes are from Büttner's publication, and the reader is referred to it for illustrations and details.

Schröder, in a lecture in Leipzig in 1932, laid down the principle that "precision working" conveys a dual idea of polish and accuracy. Polish comprises the production of a finer sur-

face condition. Accuracy goes further; it comprises *(a)* the just-mentioned surface condition, *(b)* the geometric state, and *(c)* the accuracy of the part. Given these general ideas, it is next important to have numerical information on the above conditions for the various fabrication processes involved in precision working, such as precision turning, precision drilling, precision grinding and lapping.

In precision turning and drilling, the balance and vibration in the machine, as well as the deformation due to the stresses at the cutting tool, the fit and clearance of spindle and its bearings, and the depreciation of the circulating oil are of utmost significance in obtaining the exact geometric form of the part.

According to measurements by Vieweg, the importance of the bearing question arises only in oil films up to 100 microns (0.1 mm. or 0.004 in.) in bushed bearings and 1 to 5 microns (0.00004 to 0.0002 in.) thickness for ball bearings. (Many ball bearing specialists believe that the thicknesses of the oil coatings are even less, being practically nil in ball bearings running without any trouble, if only the heat produced is rapidly dissipated.)

To obtain higher surface quality (smoothness) it is well known that high cutting speed is necessary, which produces those "flowing chips" characteristic of the production of a polished surface. Only the diamond and hard metal carbides are used for cutting tools to produce this highest surface quality; the diamond always gives the better surface condition, irrespective of the cutting speed. Light metals and their alloys, as well as brass, bronze and cast iron, are best suited to precision turning and drilling. With steel there is the problem of a really smooth surface, without any solution in sight, even at the higher cutting speeds.

In order to obtain numerical information concerning the maximum accuracy obtainable with precision turning, a group of brass cylinders 25 mm. diameter and 100 mm. long were turned with 0.01 mm. feed. The accuracy so far attainable is such that the deviation out of round or conicalness is only 0.001 mm. per cylinder (1 micron or 0.00004 in.).

Büttner describes many tests to determine surface quality. The one by Schmaltz (Zeiss manufacture) is particularly noteworthy. A very narrow light ray is reflected on the part parallel to the cylinder axis and observed in a microscope with the lighting apparatus inclined downward. Contours of turned and ground specimens may be obtained photographically at moderate magnifications in this equipment, or the height of the surface irregularities can be measured directly with an ocular micrometer, in micron units.

Returning now to the various machine operations, precision grinding is primarily applied to hardened steel parts. Accuracy in this case is favorably influenced by lower speed of the part. Common troubles are due to harder micro particles uncovered in the metal, grinding spindle being out of balance and consequently vibrating, and unsteadiness of the grinding wheel. On round specimens and in thread grinding, defects occur which are on the order of 1 micron (0.00004 in.) in size.

In lapping, the quality of the tool is the determining factor for the desired refinement, while the machine itself, in contrast to turning and grinding, is a secondary factor. In discussing various processes, Büttner gives the following numerical values regarding the difference in scratches or grooves left behind after grinding and the surface quality obtained by lap grinding and by lap polishing. The depth of the still noticeable grinding grooves is from 1.5 to 0.1 microns (0.00006 to 0.000004 in.). After lap grinding the irregularity in the surface from the highest to the deepest points is about 0.2 micron (0.000008 in.). In contrast, after lap polishing, the irregularities in surface condition here are 0.06 to 0.04 microns (0.0000025 to 0.0000015 in.).

HANS DIERGARTEN

TORSION VS. BEAM IMPACT TEST

LENINGRAD, *U. S. S. R.* — The figure on page 78, reproduced from Luerssen and Greene's article "The Torsion Impact Test" in *Proceedings* American Society for Testing Materials, 1933, page 323, shows a noteworthy discrepancy between the results obtained by their torsional method and the bending method (un-notched Izod). Howard Scott, in discussing this paper, pointed out the above fact, which has not yet been explained, despite exhaustive studies on the structure of quenched and drawn toolsteel made by the original authors. I believe that the explanation rests in the dualistic nature of steel fracture, which may be either "brittle" or "tough."

Brittle fracture occurs when for some reason the stress in the metal exceeds the so-called "brittle strength" before the yield point is reached; the cohesive *(Continued on page 78)*

Some New Chromium Alloys

PILZEN, *Czechoslovakia* — A family of interesting iron alloys, containing high chromium and moderately high silicon and carbon have recently been placed on the market by the Skoda Works. If the object is intended to resist oxidation at high temperatures, the trade name of the alloy is "Ferchromit"; if the service is to resist chemical corrosion at ordinary temperature the alloy is called "Neochrom," although the composition of each may vary within substantially the same range, namely 0.1 to 1.5% carbon, 0.5 to 2.5% silicon and 22 to 30% chromium. For forgings the content of carbon lies at the lower limit; for castings it is at the higher limit. The content of silicon is chosen according to the content of carbon; with an increase in the latter the silicon is also increased.

The scientific work in the laboratory of the Skoda Works, done by the undersigned, E. Valenta and our associates, was based on the ternary system Fe-C-Cr. The form of this diagram shown on page 57 is due to publications of Westgren, Küttner, Friedmann and their associates, as noted in the list of authorities alongside the diagram. We at the Skoda Works have endeavored to work out the pseudo-binary systems shown at the lower edge of page 57.

In the ternary system the Fe-Fe_3C diagram and the Fe-Cr diagram are well known. The binary system Cr-Cr_7C_3 is noteworthy for showing the existence of cubic carbide Cr_4C, indicated by a concealed maximum because it is decomposed at its melting temperature to trigonal carbide Cr_7C_3 and chromium. The carbide Cr_4C can contain up to 30% of iron in solid solution. The pseudo-binary system Cr_7C_3-Fe_3C represents a normal eutectic system. The iron carbide dissolves 12% of chromium at the eutectic temperature, whereas the trigonal carbide dissolves 55% of iron in the form of solid solution.

The area of the liquid of this ternary system — as is shown in black lines on the horizontal projection — is divided into five regions. The regions for primary solidification of the various phases are lettered as follows: Alpha solution *a-b-c-k-i-a;* gamma solution *i-k-j-b-i;* Fe_3C *f-g-h-j-f;* Cr_7C_3 *d-e-f-j-k-l-d;* and Cr_4C *c-d-l-c.*

Of the four non-variant equilibria existing in this system one is shown in red on the horizontal projection. It is the plane of the ternary eutectoid at 700° C. These red lines indicate how the chromium concentration in the alpha solid solution decreases in the three-phase equilibrium α + (Cr, Fe)$_4$C + (Cr, Fe)$_7$C$_3$.

The new alloys Neochrom and Ferchromit are located near the intersection of planes X_1-X_2 and Y_1-Y_2. The approximate structural diagrams on such planes are shown in black at the lower edge of page 57. It will be observed that the structure of these alloys is (when in equilibrium) an alpha solid solution and the cubic carbide (Cr, Fe)$_4$C.

Red lines and notations on these two pseudo-binary diagrams indicate how 2.5% silicon displaces the phase boundaries. (In these quaternary complexes the composition of the carbides is not known; consequently they are noted as XC.) It is clearly seen that silicon substantially decreases the region where the homogeneous gamma phase is stable, whereas the region of primary crystallization of the alpha phase is markedly increased. Further, silicon strongly raises the critical points, thereby increasing the region where alloys have no transformations in solid state (if transformation of carbides is left out of consideration). This latter circumstance is of special value for castings with a high content of carbon, since repeated transformation of alpha to gamma and the reverse, accompanied by a volume change, should have an unfavorable influence on the behavior of a casting subjected to variable temperatures.

The grain size of Ferchromit or Neochrom castings cannot be modified by heat treatment because these alloys, especially at the high content of chromium and not too high in carbon, have no transformation in the solid state. As with all alloys of this type, the grain is coarse, especially in large castings.

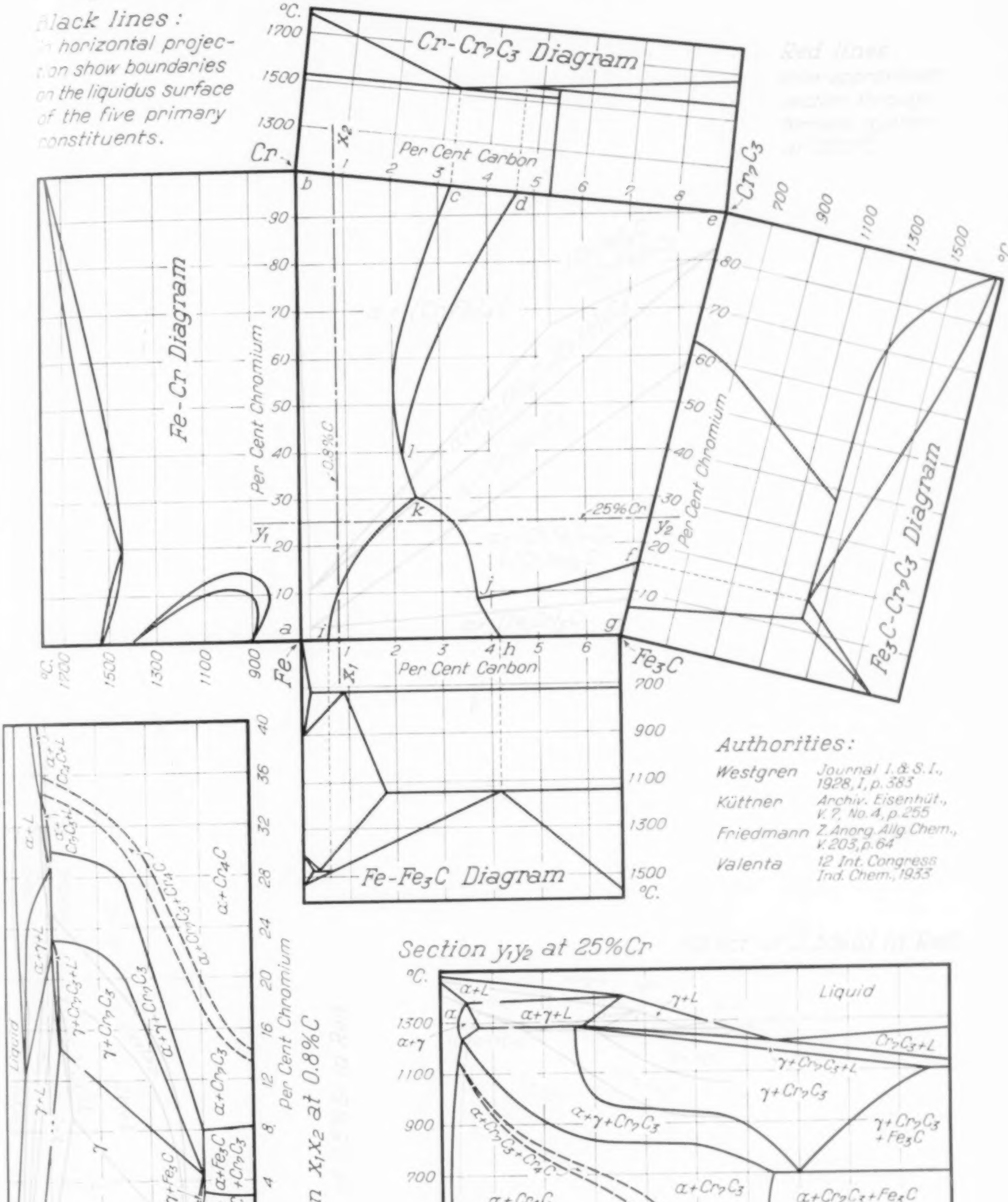
Therefore additions of titanium were tried to obtain a fine primary grain. Results were very remarkable as shown by four basic electric heats. These contained about 25% Cr, 1.5% Si, and 0.70% C. Average grain size in cast test pieces without additions was 325,000 μ^2, and with 0.30% Al addition 650,000 μ^2. With 0.40% Ti addition the grain measured only 2940 μ^2. With 0.25% Ti and 0.10% Al it was 3570 μ^2.

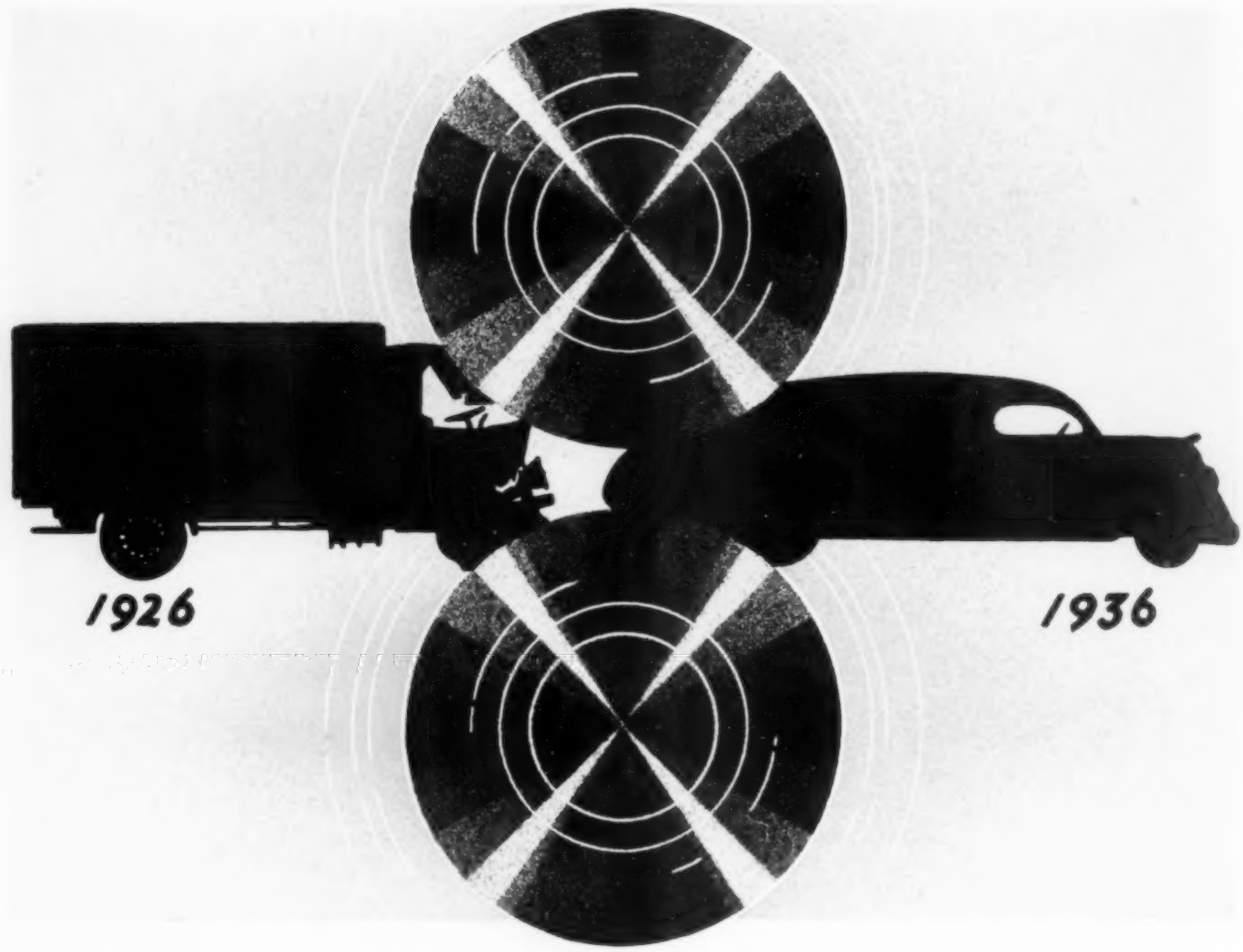
Similar results were obtained with a series of melts made in a small high frequency furnace and cast in small test bars. Over a considerable range of chemical composition the melts without titanium had average grain size of 9.1 to 11.4 sq.mm.; with 0.06 to 0.15 residual titanium the grain size was 0.40 to 0.76 sq.mm.

The influence of titanium manifested itself not only in lowering the grain size, but also suppressing entirely the dendritic structure and the columnar crystallization zone in the ingots.

F. Pobořil

Diagrams for Iron-Chromium-Carbon-Silicon Alloys





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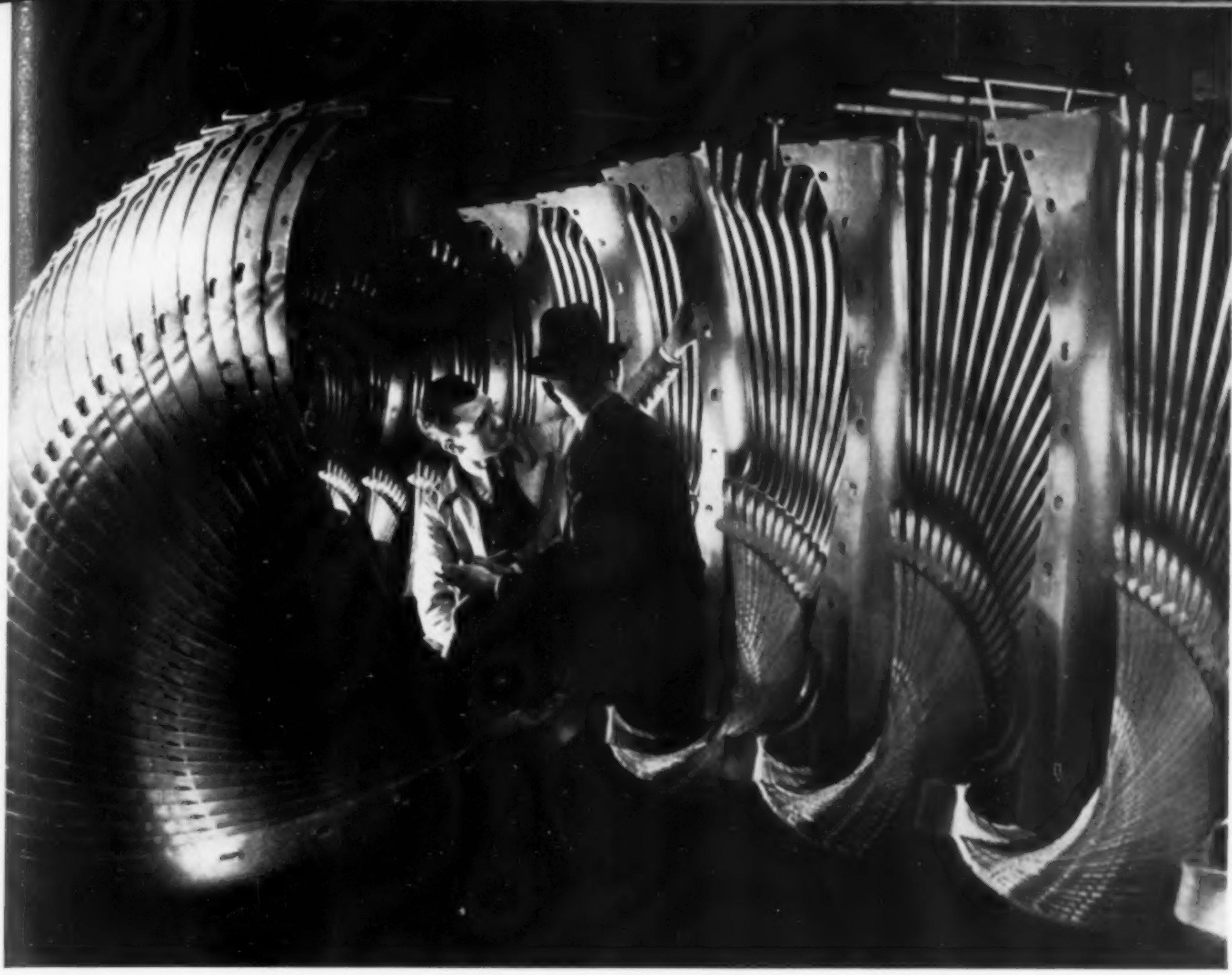


AN UNUSUAL FENDER JOB

BY JACK BEAUDOIN
Process Engineer, Sheet Metal Division, Buick Motor Co.

SEVERAL THINGS are noteworthy about the front fenders for 1937 Buicks. In the first place, they are near the top limit of size, including in one piece a cavernous fender flanged out to meet the runningboard at one end and the engine hood at the inner edge. (Formerly the tendency would be to make such a piece in at least two easier parts and flash weld them together or cover the flanged joint with a decorative beading of bright metal.) In the second place, they are made in a unique machine-line, where as many as four sets of dies for as many operations are mounted in a single mammoth press.

It all started last year when Buick resolved to stamp the deepest one-piece front fender then known to automobile industry. When this design was put up to Harry Herron, superintendent of the sheet metal division, he staked his reputation as well as a good hat on the ability of his staff and the press shop to work out the sequence of operations and unique dies required. Success in this job involved its responsibilities! When it was finally going well, it looked so easy that the stylists proceeded to model the lines and curves for a bigger and better — well, at least a bigger and deeper front fender for the new 1937 cars.

Naturally much preliminary experience was available — some of it acquired on the 1936 job. Some unusually large presses were required for it, not only large in bed dimension but long in stroke. In fact, some of the small presses already in the shop — large enough to do minor operations on the ends — had to have their frames lengthened about 4 ft. with heavy cast steel spacers to hold the deep dies required. This, together with a desire to economize on floor space in an overcrowded shop, led to a consideration of the economics of mounting multiple sets of dies in large presses rather than buying or remodeling small presses for the unit operations.

When we got the preliminary drawings for the present fender, we first modeled the fender in plaster of paris to see how it would look, and then started to work on temporary dies which would produce sample metal fenders quarter-size. After considerable cut-and-try, the first quarter-scale fenders were drawn successfully, and it was evident that it would be impracticable to trim the entire stamping in one operation as had been done in the past, owing to the intricate cam-operated die that would be required. Instead, it appeared that four trimming and associated operations could be set up in the large press used for trimming the 1936 model. (Photo on page 62.)

Advantages of Multiple Dies

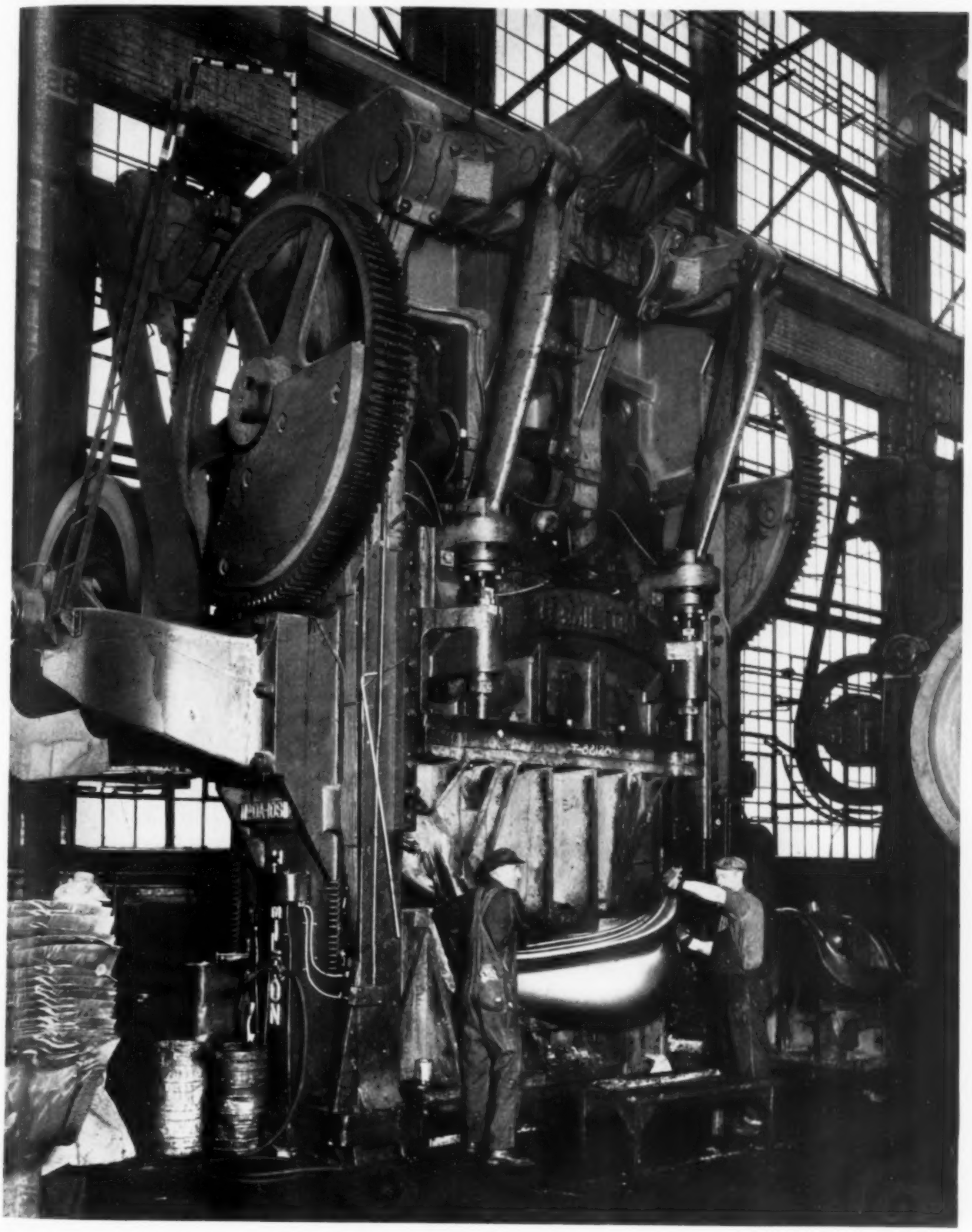
Experience with this multiple set-up on big presses indicates a number of economies. The over-all cost of one large press is less than of four smaller ones, and it is more adaptable to future changes in dies. The floor space required is less. Since the dies are considerably closer together, there is less handling labor (no small matter in parts weighing 55 lb. each), no stack of parts between presses, and less chance for scratching and denting. There are fewer workmen of "press operator" classification and proportionally more of "helper" classification. Finally, the entire series of presses keeps in step with the first forming operation, and a good leader at that position will set the pace for the whole crew.

Only those concerned with modern die making and press shop practice can appreciate the time and effort and the headaches involved in the production of a new stamping of this character — the building of dies, the tryout, and the constant attention to fine details required to smooth out the lines and mold the curves. It's discouraging work at first. You start the run with more rejects than good pieces and then little by little as the die dressers stand by and grind here or smooth there, the final form of the dies takes shape and the stampings begin to come through. Many times a slight variation in area or pressure of the gripping dies, the insertion of a short bead for even tighter grip, or the generous lubrication of a certain area will make the difference between success and failure. I am glad to say that metallurgists from the sheet mills are of great help in solving these difficult problems; they are always ready to study our requirements and modify their rolling practice and annealing cycle to adjust the material to the part in the shop.

To get some idea of the amount of stretching that takes place in this front fender, a sample blank was put through the presses, the flat sheet being scribed with 2-in. squares over its entire surface. Starting with a blank $92\frac{1}{2}$ in. long, the forming operations stretched the metal to $102\frac{1}{2}$ in., an over-all extension of 10 in. or around 11%. The biggest stretching takes place at the rear end of the fender. Here a 2-in. square was pulled out to $2\frac{9}{16}$ in. by $2\frac{13}{16}$ in. — stretching $\frac{9}{16}$ in. in the width and $\frac{13}{16}$ in. in length. At this section the local elongation was about 41% lengthwise and over 28% in the width. Elongations in tension test pieces of 19-gage sheet steel (0.042 in. thick) of 41% in 2 in. are by no means surprising, but remember the metal then is free to contract laterally, whereas in a deep drawn stamping the elongation occurs simultaneously in all directions except thickness. This stretch causes a corresponding thinning, but the work hardening is sufficient to counteract the loss in section as far as eventual strength and stiffness are concerned.

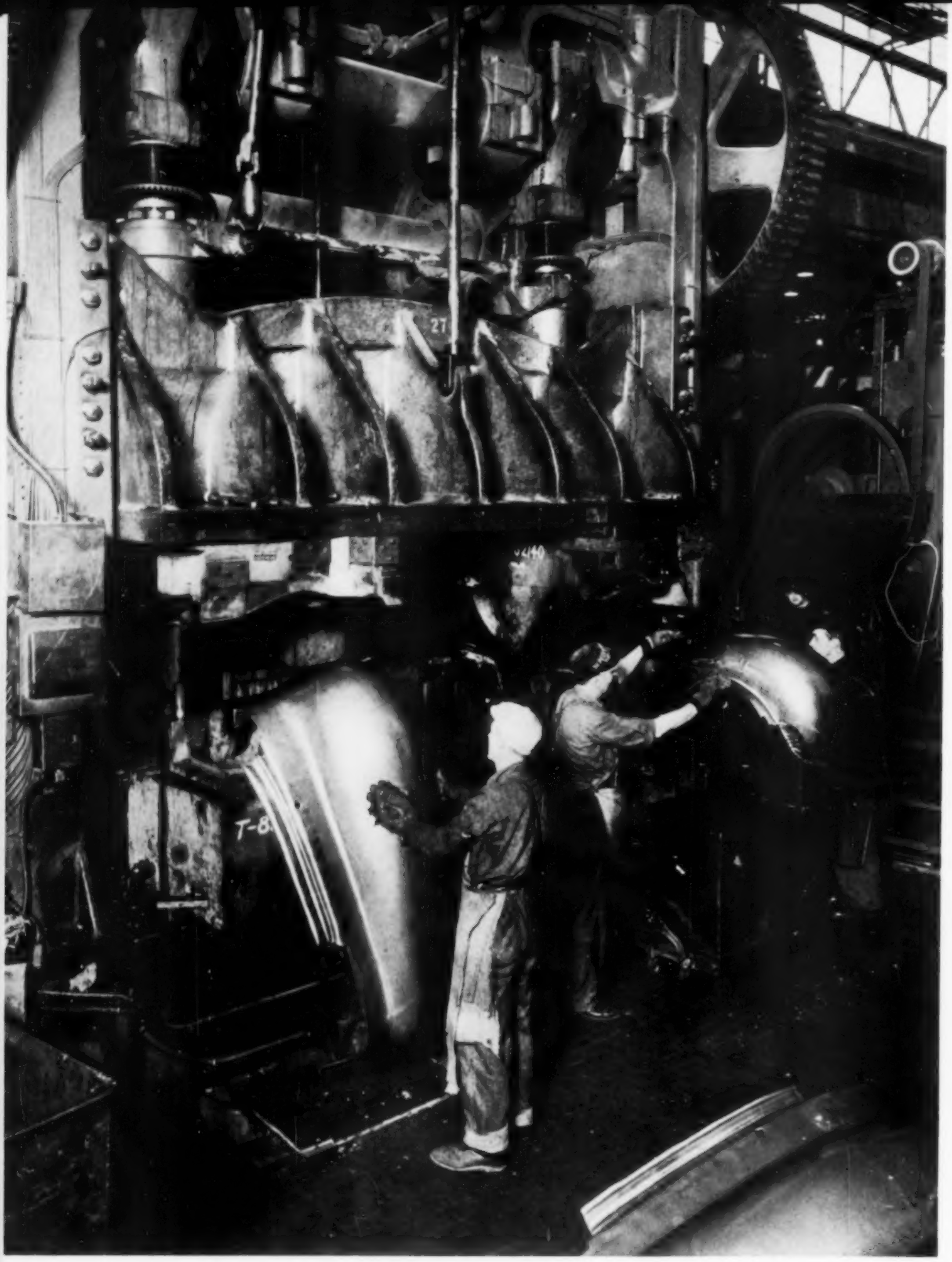
After blanking the sheet, it is put through a set of staggered rolls to flex the sheet back and forth several times, thus putting the metal in a plastic condition where it will draw free from "worms" or "alligator markings." This machine is quite similar to a roller leveler used in a sheet mill; a dozen rolls, six above, six below. The rolls are of relatively small diameter and to avoid spring are backed up with others, held in the stiff top and bottom frame.

The first heavy draw is shown on page 61; it takes a double-action toggle press with bed 8 ft. by 11 ft. in area. Prior to placing the blank in the dies, it is painted at certain strips along the edge (both sides) with a pasty drawing com-



Double-Action, Toggle Presses Drawing Front Fenders for 1937 Buicks

Rejects after first draw are piled at left; the characteristic of this press line-up is that fenders progress from die to die, all working in step, so there is no stock cluttering up the floor



Four Operations, Performed in as Many Sets of Cam-Operated Dies, Are Done at One Stroke of This 60x148-In. Press. Many economies result from such multiple set-up in a single large machine

pound, and some corners bent up by hand. Four men are required on the feeding side to do this work. The press operator and his helper on the front loosen the rough stamping from the lower die and pass it on to the next machine in line. Production is about 100 per hr.; rejects due to large breaks and tears have been as low as 1% for a shift, which speaks volumes for the success achieved on the job; rejects due to rolling mill defects (principally laminated sheet) may run up to 3%.

From this point on follow a series of multiple die set-ups that I believe are unique in the metal stamping art. Operations No. 5 and 6 in this series are combined in one press using two different dies. Number 5 rough trims and restrikes the rear end; No. 6 cuts scrap at the front of the hood sill. These operations are performed on a press with 36x96-in. bed.

In similar fashion, operations No. 7 and 8 are handled on another large double-action press like the one used for the first draw. Here again are two separate dies; one for trim and first redraw of nose end, the other for finish redraw of nose end. The latter is done in a cam-action die, where the pressure is maintained by a pair of hydraulic cylinders set horizontally (there being not enough vertical distance between upper and lower heads of the press to allow this to be built in-line).

The picture on this page shows conditions typical of the multiple die set-up in a single-action press with beds 60x148 in. in area. Operation No. 9 is shown at the left, a rough trim on the nose end. This done, the fender is turned end to end and operation No. 10 (two men at right) finish trims and flanges the runningboard end in a cam-action die. The fender is then skidded on a table to the rear of the press, inserted in operation No. 11, where the hood sill is finish trimmed and flanged in a long, narrow die just seen above the workman's white cap. Operation No. 12 (hidden at the left end, rear side) is to finish trim and flange the nose end and bumper hole. While these operations have been described by routing a single fender around the press, it should be understood that all dies are full at each stroke of the press.

Operation No. 13 — finish trim and flange outside — is handled on a 60x84-in. press. Operation No. 14 trims and flanges the radiator connection; the last operation, also on a small press, is the piercing of two holes.

The foregoing covers the principal press shop operations in the forming and finishing of the fender stamping. At the end of this series, all in step, the fender is degreased by going through a washer and gas dryer. Twelve additional operations are required before the fender is ready for the paint shop. These include curling of the flanged outer edge, reflanging of runningboard, and a number of finishing and repair operations. The latter include fixed and portable hammers (where minor wrinkles are bumped up), oxy-acetylene welding of incipient cracks at the trimmed edges, and hand filing or grinding slightly roughened areas as indicated by the inspector.

Interesting Jig for Welding

One notable development concerns the attachment of the splashers or fender skirts, which really constitute the side of the engine compartment below the curving fender line and above the chassis frame. This year, the fender skirt, which serves as the splasher at the hood sill, is made up of three stampings, welded in one set-up operation to the fender. The machine is photographed on this page; it has automatic clamping fixtures holding the laps tightly against a copper bar, bent and shaped to proper contour. The spot welding is done with a hand-grip gun welder. This is moved quickly from point to point along the seam; a trigger is pressed, and air pressure forces the welding electrode down on the seam (the upper end of the air cylinder being held by a "bucker-up" bar above) and when the pressure reaches the correct intensity an electric switch closes automatically, discharging current of proper spot welding characteristics for the proper time from electrode to copper clamping bar. Duration of the current is also controlled by time release.

With this construction, all holes for fastening the fender to the frame are incorporated in the skirt instead of the fender stamping so that any changes required in the attachment can be readily made in the small skirt fastenings. Previously it was necessary to make costly changes in the large dies to accommodate changes in the fastening holes.

A final word is in order about the metal from which the dies are made. Ordinary cast iron dies of this size run into great weight — in fact, beyond the safe limit of our 15-ton crane and craneway. Note the relatively thin webs and bases on the dies in the photograph on page 61. These dimensions are possible (and at the same time staying within our weight limitations) by using nickel cast iron dies, an electric furnace product made locally. While these are rather more difficult to dress than older dies, they are practically indestructible from wear.

Fixture for Assembling Fender and Fender Skirt Stamping, Ready for Spot Welding With Hand "Gun." Current is flashed on automatically when correct pressure is established between point, lapped sheets, and copper bar beneath

One of the most important tools the practicing metallurgist has — in fact any professional man — is a living library. Books form the basis of it; periodical literature is the growing organism constantly bringing the state of knowledge up to date. Unfortunately the time required to collect comprehensive information, write and print the book means that editions can be prepared at rather rare intervals — in them the state of the art seems to be static. On the other hand, in handbooks such as the two described below, re-issued at fairly frequent intervals, metallurgy is a living organism, as we all know it is, growing vigorously.

REVIEWS OF RECENT BOOKS

Metals Handbook

Reviewed by Fred H. Colvin
Editor, American Machinist

A.S.M. Metals Handbook, 1936-1937 Edition. 1392 pages, 6x9 in. Red cloth binding. American Society for Metals, Cleveland. Price to non-members of the Society $10.00.

Only those who have had experience in the preparation of large books of reference can fully appreciate the care and labor represented by this new volume. As with all other such books, one of the most serious problems that confronts the authors or compilers is what can be omitted. For there are so many phases of modern metallurgy as it applies to present day machinery that it is not possible to include all the data available.

The major headings, as outlined by R. S. Archer, president, are: General Data, Construction of Matter, Structure, Properties, Testing, Melting, Casting, Mechanical Working, Heat Treatment, Machining, Grinding, Welding, Soldering, Cleaning, Equipment and Application. This list, however, gives but a faint idea of the amount of material contained in the book, as can be seen by a close study of the 38 pages of closely set index, and a table of contents that requires 7 pages.

The section devoted to the testing of metals seems particularly complete, both for laboratory and shop use. It includes a complete discussion of Brinell, Rockwell, Shore, Monotron, Vickers, Herbert and other hardness testing methods, covering well over 50 pages. The effect of design on heat treatment is shown by numerous illustrations of a very practical nature, while the data on the welding and casting of metals is given in very concise form.

It is impossible even to refer, in an adequate manner, to all the subjects covered in this volume. The information regarding the trade names of steels of various kinds and the constitution of the various alloys, will commend the book to all who have to do with ferrous metals and the machining of them. Likewise the data regarding the tools to be used, machinability, cutting fluids and the like will be welcomed by many.

Approximately 475 pages are devoted to non-ferrous metals and their properties. The information includes the uses of the materials as well as methods of machining and of welding. Nor is this confined to the more common metals. It includes platinum, palladium, iridium, osmium, rhodium and ruthenium.

Another feature of the book is the insertion of colored pages, advertising the materials or apparatus referred to in the section adjoining

the insert. These pages give information that the reader frequently wants where it is easily available and in a distinctive manner. These insert pages, however, all bear separate numbers and are not counted in the 1392 pages of text, nor can they be confused with the text in any manner.

Sources of information are given in nearly every case and there are frequent references to additional data on the subject to be found elsewhere. These references number about 2500 and add greatly to the value of the volume as a book of reference. Metals working plants should have one or more copies of this Handbook available in their libraries and should encourage their men to use them frequently.

Cast Metals Handbook

Reviewed by E. J. Donnellan
Secretary, ⊕ Metals Handbook Committee

Cast Metals Handbook. 512 pages, 6x9 in., 125 tables, 130 illustrations. Semi-flexible cloth binding. American Foundrymen's Association, Chicago. Price to non-members of the Association, $4.00.

By the publication of the 1935 edition of Cast Metals Handbook, the American Foundrymen's Association has rendered its industry a valuable service. This is the first edition and, we believe, the only Handbook published dealing only with cast metals and casting problems.

With the advent of welded structures and the development of many new high-strength wrought alloys, the casting industries suffered, for a period, a loss of business to the producers of wrought products. This loss of business was frequently attributed to a lack of readily available and authentic information on the properties of cast metals, manufacturing practices, and a knowledge of the proper application of cast materials in relation to design. Although much engineering data have always been available on casting problems and materials, they have been distributed throughout the technical literature, and when certain portions of these data were organized into a compilation, they were available to only a few. As a result the purchasers of castings, engineers, and often foundrymen themselves, have been handicapped by insufficient information and too often have applied obsolete data to their problems. Cast Metals Handbook now places at the disposal of all those interested in castings a valuable compilation of engineering data, thus removing the former handicap and assisting them in arriving at the same conclusions as to costs and service results to be expected from castings.

The Handbook is divided into six major sections. The first section contains 26 pages for the designer, giving recommendations as to the design and types of patterns, suggestions for such important subjects as thickness of sections for different metals to be cast, solidification, fillets and cores in order to produce sounder castings more economically.

The second section of the book lists recommendations to buyers of castings. Although this section only contains five pages, it gives sound advice to the purchaser as to the type of information that should be submitted to the foundryman in order to arrive at cost figures and avoid misunderstandings.

The next four sections of the Handbook discuss cast materials and devote a section each to cast iron, malleable cast iron, cast steel, and non-ferrous castings.

The methods of manufacture for the various cast materials such as patterns, molding, cores, melting, casting, cleaning, and heat treatment, are discussed each in its own division. The metallurgy of each metal is also outlined — such phases as structure, effect of alloying elements and impurities, physical changes and transformations, composition, and control of properties.

The subdivisions of each of these sections present for the cast metals comprehensive information and engineering data on the properties such as chemical, mechanical, electrical, hardness, corrosion resistance, machinability and strength at elevated temperatures. The generous use of tabular matter and charts presents this in convenient and useful form.

In a number of subdivisions suggested applications for the cast metals are listed as a guide to the proper use and as an illustration as to the extent the particular metal is used. Some of the more important and generally used specifications and tests are listed and discussed for the various cast materials.

It is interesting to note that the book has departed from the conventional 4½x7-in. handbook size and is produced in the much more convenient and useful 6x9-in. text book size. We do not hesitate to recommend Cast Metals Handbook to anyone having to do with castings and foundry problems. It should serve as a valuable reference volume for engineers, consumers, and producers of cast metals.

Testing With X-Rays

Reviewed by H. H. Lester
Senior Physicist, Watertown Arsenal

Engineering Radiography, by V. E. Pullin. 136 pages, 8x11 in., 30 illustrations. G. Bell and Sons, Ltd., England. Marketed by Engineers Book Shop, 168 East 46th St., New York City. Price $16.00.

Radiography is very deeply indebted to Dr. Pullin for much of the pioneer work that has given this method of testing metals its present recognition. This, his latest contribution, is a very welcome addition to the extensive literature on the subject. It may be described as a compendium of useful information covering the field of metallurgical applications of radiography. The volume is divided into six chapters, and comprises 44 pages of text and 92 pages of illustrations — a notable preponderance.

The text, written with characteristic lucidity, is a sufficiently complete and admirably condensed treatment which will appeal alike to the practical technician and to the metallurgical engineer. It commands respect because of its simplicity and conservatism.

The illustrations deserve special comment. They are remarkable for their excellent execution, but more important they convey pictorially stories of case histories that could not have been presented as well otherwise. These case histories cover the typical examples of casting defects. They are shown in radiographs together with pictures of cut sections and are further elucidated in many cases by cross-sectional drawings of the piece.

Special methods used for various difficult problems that arise in practice are also discussed in the text and further illustrated by sketches and diagrams. The treatment of welds is worked out with the same meticulous care, although unfortunately it is somewhat lacking in completeness.

The chapter on radiography by gamma rays is perhaps the most valuable discussion that has yet been presented on this interesting subject. The illustrations again drive home the points made in the text in a convincing manner.

In the chapter devoted to X-ray equipment it might be remarked that some important recent developments in this country are omitted. This chapter could be improved by descriptions of shielded anode tubes, grid tubes, and self-rectifying units now coming into use in a number of places in the U. S. A.

Physical Metallurgy of Iron

Das Technische Eisen (Constitution and Properties of Iron and Its Alloys). 3rd Edition. Revised and enlarged from the second edition (1925) of the late Prof. Paul Oberhoffer's volume by W. Eilender and H. Esser. 642 pages, $6\frac{1}{2} \times 9\frac{3}{4}$ in., 762 illustrations, bound in black cloth. Published by Julius Springer, Berlin W-9, Germany. Price 57 RM (subject to export discount).

Here is a fitting companion for Eduard Houdremont's volume on alloy steels, which the Editor so enthusiastically reviewed in Metal Progress for September 1935. If to these two books Franz Rapatz' *Die Edelstähle* is added, the picture of German steels is notably modern, clear and complete.

At the very start the title illustrates the fact that Germans and Americans look at things from different angles. Professor Oberhoffer first wrote a book about the technology of iron; his plan has been retained and certain portions highly developed by his associates at the Metallurgical Research Institute in Aachen, so that an American technologist would class this book not as technical, commercial or engineering metallurgy but as physical metallurgy, scientific or theoretical rather than practical. Thus, half of the book is devoted to an exhaustive discussion of 27 binary equilibrium diagrams of as many chemical elements with iron, the corresponding ternary systems with carbon (where they have been studied), and the way specific properties vary as the structure changes. These diagrams and discussions extend far beyond the present limits found useful commercially — for instance, an American technologist would stop thinking much about copper in steel after reaching 2 or 3%; this text gives the binary system up to 100% copper, the ternary system up to 25% copper, and properties up to 5% copper. (This remark is intended to illustrate an advantage rather than a defect of the book.)

The second half is subdivided by operations and practices rather than by materials, although two short chapters at the very end have to do with malleable and cast iron. A very valuable section comprising 110 pages, more or less, discusses solidification of ingots and castings, the crystal structure, segregation and ingot defects, and the way all these things affect the microstructure and properties after subsequent treatments, either in the steel mill, the foundry or the plant of a machine manufacturer. Another in-

dication of the authors' point of view (inherited from a scientific rather than a technical or practical background) is that they devote 25 pages each to hardening theory, case hardening and age hardening.

In other words, this is a book for men who are looking forward, rather than for those interested in maintaining the metallurgical status quo or reverting to the ways of our fathers — if there are any such. It is, as already intimated, distinctly a Teutonic book; while many Swedish, French and English authors are mentioned in the bibliography (together with a handful of our own top-notchers), the bulk of the material is drawn from a galaxy of German investigators. In view of the relative ignorance we Americans have of the foreign literature, a summary statement of this enormous mass of knowledge is in itself of immense convenience. It is as though the German contributions referred to in all the Alloys of Iron Monographs were condensed into one inclusive volume.

E. E. Thum

NEW PUBLICATIONS RECEIVED

Symposium on High Strength Constructional Metals. 126 pages, 6x9 in. Published by American Society for Testing Materials, Philadelphia. Paper bound \$1.25, cloth \$1.50. Reprints of five papers and discussion at Pittsburgh regional meeting, March 1936, devoted to light metals (E. H. Dix, Jr.), copper (C. H. Davis), nickel (G. F. Geiger), steel (E. F. Cone) and stainless (E. E. Thum).

Aircraft Tubing Data. Loose leaf binder containing 40 pages, 8½x11 in. Published by Summerill Tubing Co., Bridgeport, Pa. Price \$1.00. Properties of standard sizes of round, square, elliptical and streamline tubing, but mostly curve sheets showing relation between load and column length of such chromium-molybdenum tubing for fixity values of 1 and 2, and yield points of 60,000, 75,000 and 85,000 psi.

Standard Metal Directory, 7th Edition. 676 pages, 6x9 in., blue cloth. Atlas Publishing Co., 150 Lafayette St., New York. Price \$10.00. A directory of the metal refining and casting industry, both non-ferrous and ferrous, giving not only the business address, but in most cases, names of officials and lists of facilities available. The 6th edition was dated 1931.

Zinc Coating (Hot Galvanizing). A bibliography compiled by Victor S. Polansky, Carnegie Library, Pittsburgh. 110 pages, 8½x11 in., mimeographed, unbound. A list of articles and patents since 1910 that are available at the Carnegie Library, with brief notes on the scope of each citation. Books and other publications containing additional lists of references are clearly marked.

Iron and Steel Wire. A bibliography compiled by Ralph H. Phelps, Carnegie Library, Pittsburgh. 68 pages, 8½x11 in., mimeographed, unbound. References (and notes on scope) dating back 50 years to books and magazine articles referring to history, manufacture and properties (except electrical). Rolling, pickling and galvanizing of rods are not treated.

Agathon Alloy Steels. 106 pages, 6x9 in., blue cloth. Republic Steel Corp., Alloy Steel Division, Massillon, Ohio. A handbook, handsomely illustrated and printed, concerning the manufacture, properties and uses of the S.A.E. alloy steels, as well as several other useful groups of low chromium steels, nickel-chromium-vanadium steels, nickel-copper-molybdenum steels and chromium-molybdenum-aluminum steels.

Fourth Report of the Corrosion Committee. 239 pages, 5¼x8½ in., 52 line drawings, 11 plates, bound in maroon limp cloth. Published by the Iron and Steel Institute, 28 Victoria St., London, S.W. 1, England. Price 16 shillings. Various steels and irons are being exposed in racks to the atmosphere in a number of locations, and built into ship hulls for marine exposure. Supplementary laboratory studies have also been undertaken on correlated problems. Some atmospheric exposure tests of 5-year duration on chromium-copper steels and manganese-copper-silicon steels (analogous to the high strength structural steels recently exploited in the U. S.) are now available.

Second Report of the Steel Castings Research Committee. 117 pages, 5¼x8½ in., 126 illustrations, bound in maroon limp cloth. Published by the Iron and Steel Institute, 28 Victoria St., London, S.W. 1, England. Price 10 shillings. Reports of six subcommittees on such matters as fluidity and its influence on the casting, measurement of casting temperatures, the properties of the steel during cooling in the mold.

Major Bellis was first chairman of the Springfield Chapter on its organization early in 1920, as a unit of the rapidly growing American Steel Treaters Society. Then metallurgist of the Springfield Armory, famous for a century for its army rifles, he acquired certain ideas about the best way to heat treat the tools necessary for machining the barrels and various parts of the breech mechanism. These ideas he has exploited to commercial success in salt baths and furnaces that have far wider applications than the original ones in tool rooms

MOLTEN SALT BATHS INTERNALLY HEATED

BY A. E. BELLIS

A NEW METHOD for heating molten salt baths, used for heat treating high speed steel from high temperatures (2300° F. more or less) was developed in 1928. Instead of putting the pot in a fuel fired setting and transmitting heat through the pot wall to the salt within, the pot was supported all around by insulating firebrick and heat generated by passing current from a submerged electrode through the salt to the pot wall. For heating of high speed steel tools, three pots were commonly mounted in a row in one refractory block, one at moderate temperature for preheat, one at high temperature for final heat, one at the correct temperature for quenching. Equipment of this sort was described by the present author in METAL PROGRESS in January 1934. It is now the intention to give some additional information concerning the economics of larger installations for treating steel and non-ferrous metals at lower temperatures.

The early furnaces usually had a single electrode in each pot, being intended particularly for the high temperature work where it was best to use as small pots as possible. Double electrodes would occupy too much of this valuable space. However, tempering, preheating, quenching and annealing at lower temperatures as well as high heat baths for large pieces were soon in use which employed several electrodes, the current being passed either between the multiple electrodes or the electrodes and pot wall.

Since the pot itself is of metal and, therefore, a conductor of electricity, it might be assumed that it would short circuit the current — in fact, neither the metal pot nor pieces of the work heat treated coming into accidental contact with the electrodes did so. The highest resistance seemed to be near the electrodes, yet circulation of the bath prevented local overheating. It will, of course, be understood that a metal pot is absolutely necessary as a container of the bath material to prevent contamination of the bath from any refractory material which might be proposed as a container. The metal pot is also an important feature in the storage and equalizing of heat in the furnace (as will be shown in more detail later). When cold work is immersed in the bath a non-conducting film of salt freezes around it, so if cold work accidentally touches two electrodes this solid insulating film prevents short circuiting. After the load is adjusted, it, of course, rides free of electrodes. If, after this film melts off, the work accidentally shorts two electrodes, a safety switch prevents damage.

As the temperature rises, the conductivity

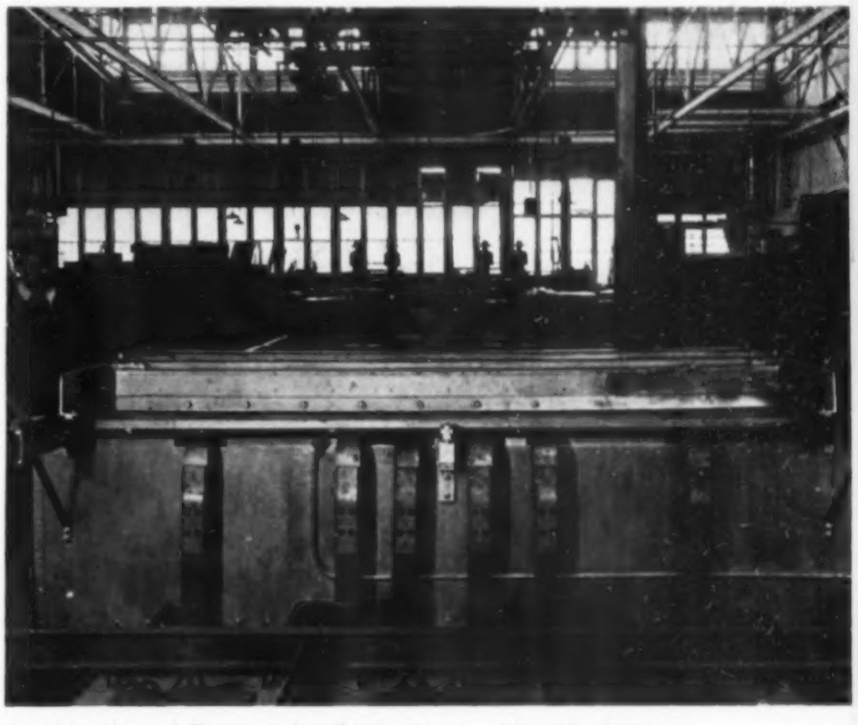
of the bath increases and therefore the current input in a typical installation rises approximately as follows: Bath with melting point of 1000° F. operating at 1200° F. requires 50 amperes, at 1500° F. the bath takes 71 amperes, and at 1800° F., 88 amperes.

Other interesting changes included the placing of electrode leads under the insulated top of the furnace; the preference for rectangular pots over round ones especially for annealing, some being over 20 ft. long; the simplification of the cover so that an insulated slab on roller bearings became the preferred type; pots of thicker and thicker walls as it became evident with tonnage production that the heat stored in the pot was a decided advantage. It was also found that castings made good pots. Some high chromium alloys, which were unsuitable for furnaces fired from the outside, have given very satisfactory life. One alloy in particular is unusually resistant to deterioration at and above the salt line, yet in the opinion of the alloy manufacturer was quite unsuitable for a container due to its coarse-grained and brittle structure. It turned out that when supported all around with brickwork, and cast with the thick walls desirable for heat storage, this alloy is extremely durable at the high heats necessary for 18-4-1 toolsteel and 18-8 stainless steel. Even at temperatures up to 2300° F. it is now possible

In order to control the current input, primary taps to the transformer are arranged to give lower primary voltages as the amperage increases with the conductivity of the bath. The line voltage (ordinarily 220 or 550 volts) is stepped down to somewhere in the range of 10 to 16 volts, by such transformer taps, depending on the temperature, conductivity and thermal requirements of the bath.

Electrodes themselves are massive hairpins of heat resisting iron alloy, one leg immersed at least 12 in. in the bath and the other leg securely bolted to copper bars of low resistance. Transformers are usually set quite close to the furnace (to make the connection as economical in copper and the I^2R loss as low as possible) either in a screened cage or a subfloor compartment. All connections must be made with as few and as good joints as possible, as the current is so high that a little resistance will cause excessive heating.

Some preliminary doubts about methods of starting up a pot frozen solid have been easily resolved. A metallic resistance coil is placed between electrodes (in small pots) prior to a shutdown. In larger baths, where space is not such a consideration, these coils are permanent, a properly designed coil taking no more than 10% of the current at operating temperatures.



Construction of Rectangular Tanks of Considerable Length, for Heat Treating Metals in Molten Salt, Is Well Shown by the Two Views on This Page. Electrodes hook over the sidewalls, are immersed in the salt inside and securely fastened outside to copper bars leading back to transformers (in this case these are housed in a pit, the protective floor slab having been removed for the photographer). The cover is well insulated, mounted on wheels and slides to one side allowing work to come in or out, via overhead crane

to guarantee pot life of one year; practically no failures occur at 2000° F. and lower.

The heat stored in the pot has led to some very important engineering developments. It became evident that a large "tank of heat" often had advantages, so that a larger bath than actually required to handle the work was often preferred. In small shops with a power demand of, say 100 kw., a furnace with this rating could be heated when the machinery was idle and store enough heat to do the necessary annealing without using more than a small part of the available power load with machinery running. Another example is in a shop where both copper and steel are to be annealed. The routine was adjusted so that the bath was preheated for 4 hr., starting at 3 a.m. and ending at 7 a.m. with off-peak power, thus bringing the temperature up above 1350° F. (the correct temperature for the steel). As soon as all the steel was heated, the moderate amount of current required to maintain temperature was shut off and enough heat was then stored in the bath to anneal several tons of copper with no current at all while the bath was cooling, but still above 1100° F. (the minimum for copper).

Stored Heat Utilized

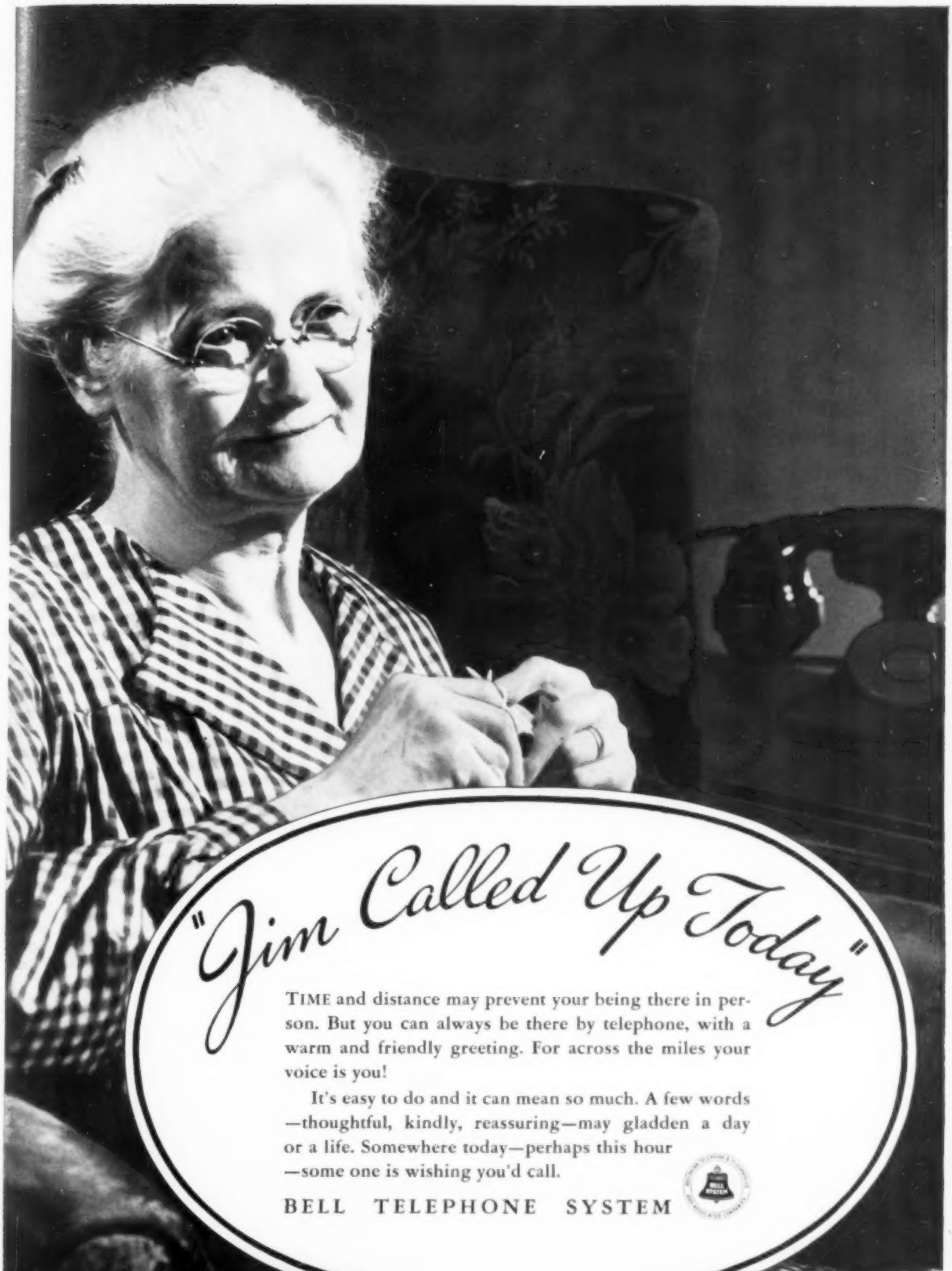
A more elaborate illustration of this plan is in a plant having to anneal various amounts of stainless steel, nickel, steel and brass. The full current is turned on the furnace at 4 a.m., when the demand for electricity at the plant is at the lowest. This current is held close to maximum until about 7 a.m., at which time the temperature of the furnace has increased to 2000° F., suitable for annealing stainless steel. Power is then turned completely off, allowing the peak load on the motors starting the plant equipment to be handled without any interference whatever. At about 8:30 a.m., when the plant is running along with a demand some 15% below the peak, a small amount of electric power is again diverted to the furnace. When the plant is shut down at noon the furnace is turned on full again until 1 p.m., when the power is completely turned off the furnace to accommodate the motor peak. In the afternoon the general procedure is repeated.

The temperature in the furnace gradually drops off through the day, due to the heat absorbed by the wire being annealed, but this drop is utilized by annealing, successively, materials which require lower and lower annealing temperatures. For instance, at 7 a.m. approximately 100 lb. of stainless steel wire is annealed at from 2000 to 1850° F. The furnace then cools down further to 1750° F. and 1650° F. during which time the nickel is heated. The furnace again cools until at 1550° F. 200 lb. of german silver wire is annealed. This brings the temperature down to 1400° F., at which point 500 lb. of steel wire is annealed and at 1250° F. 500 lb. of brass and bronze are annealed. The quantities of the different materials vary from day to day, but this is readily taken care of by adjusting the power input.

While it may not seem good practice to use a range of temperatures of 100 or 200° for annealing in this way, there is a wider range than this selected by different fabricators of the same metal as the preferred temperatures. For example, after a year's operations on annealing sterling silver, one firm decided to standardize on 1225° F. as preferred temperature, though it had started with 1325° F. One of its competitors prefers 1350° F., while still another thinks 1175° F. is the maximum annealing heat for this metal, all bought from the same brass mill to the same specification.

The above operations can be carried out in a salt bath with melting point of 1000° F., and this is the approximate melting point of the baths ordinarily used for annealing, hardening or casehardening work. Such baths are commercially supplied as dry, fused mixtures of the several ingredients in proper proportions to give a minimum melting point with proper stability, fluidity and working range. Baths used for case hardening of steel require periodic additions of carbonaceous and nitrogenous salts to replace the material lost in operating. Baths for steel hardening preferably contain boron compounds that dissolve oxide, thus preventing any decarburizing or pitting of the metal being hardened. Such baths are more efficient as a heating medium as well as more stable than baths in which oxide particles do not dissolve, and form a film which closely adheres to the hot metal when withdrawn. This protective film prevents oxidation during transfer from the heating to the quenching operation.

Baths of special compositions are useful at lower temperatures, as for tempering steel, heat treating aluminum alloys or heat treating special alloy steels. Steel tempering baths with melting points as low as 272° F. consist of mixtures of the non-hygroscopic salts, sodium nitrite and potassium nitrate. They are stable


"Jim Called Up Today"
TIME and distance may prevent your being there in person. But you can always be there by telephone, with a warm and friendly greeting. For across the miles your voice is you!
It's easy to do and it can mean so much. A few words —thoughtful, kindly, reassuring—may gladden a day or a life. Somewhere today—perhaps this hour —some one is wishing you'd call.
BELL TELEPHONE SYSTEM

up to 1200° F. and are used around 950° F. for the heat treatment of the aluminum alloys used in the airplane industry.

Heat can be exchanged between metal and baths to arrange very efficient recuperation. Where graded hardening or interrupted quenching is desired (as to avoid hardening cracks) baths at the quenching temperatures of 300 to 700° F. can be used for both preheating and quenching so that the heat removed from the high temperature furnace is returned to it in great part. The sequence of operations with a chromium ball bearing steel is as follows: Preheating at 650° F.; hardening at 1550° F.; quench in the preheating bath at 650° F. before dipping in cold oil. Such a practice can be applied also to the patenting of rope wire or steel rods for cold heading, in which case the temperatures are about 1350° F. and 675° F. in the high and low heat baths. With units heating tons of metal per hour, the recuperated heat can amount to over one-third of the direct heating cost. If three or four steps are practical, as in annealing stainless steel, even greater economy can be attained by these methods.

There is another reason why such furnaces are so economical, when compared with the cost of fuel-fired pots. One reason is that only the metal to be annealed has to be heated — heavy pots or furnace chambers do not have to be heated and cooled with each load. Very short cycles are also efficient, eliminating the furnace stand-by losses. But the real reason that this type of heating is economical is that few fuel-fired furnaces turn more than 10% of the heat units in the fuel into useful work; if the current is generated in a power plant, as much as 25% of the B.t.u. may be converted into electrical energy. Of the electricity delivered to the furnace, 95% is converted into heat and practically all of this can be delivered to the work being annealed.

Some collateral advantages are noted in such operations as casehardening and heat treating of aluminum alloys. If any scale or sludge accumulates at the bottom the heat transfer is not seriously affected (as in a fuel-fired setting); in fact, it may even increase the insulation. When applied to stainless steel the preservation of the surface from any oxidation during annealing or hardening improves the stainless qualities. It is also a convenience in getting a high heat with sufficient storage so that the cold load does not cool down the furnace greatly.

Internal heating is preferable for casehardening baths because of its ability to heat up rapidly and its high thermal efficiency. The input of current can be arranged to recover temperature as rapidly as desired, there being no lag from heat having to penetrate through the scaled metal walls and accumulation of sludge, oxides or other non-metallic particles sticking to the sides of the pot.

New Combinations of Salts

These considerations also made it clear that some bath materials that previously had been avoided could be used in this type of furnace. Thus the cheaper, though less stable calcium salts and the nitrites had been avoided because they deposited sediments too freely. Sometimes these salts had other benefits such as that of lowering the melting point. Thus it was found that a lower melting point bath was preferred for annealing sterling silver to the one used for the nickel and copper alloys. When this lower melting bath was tried in a fuel-fired furnace, it was a failure because of the deterioration of the bath, the burning out of the pot and the deleterious effect on the silver of the deteriorated salts. These effects did not develop at all in the internally electrically heated furnace; silver annealing on a production basis has been very successful and economical. This also was the case with other precious metal annealing, particularly that connected with gold plating work.

The possibilities of this type of furnace may best be appraised by some typical installations:

A wire annealing furnace with pot 6 ft. long by 4 ft. wide by 4 ft. deep and 200 kw. rating handles a ton an hour of fine wire or rods supported on yokes in charges of 300 to 900 lb. and cycles of 10 to 20 min. This short cycle results in uniformity and good physical properties, and is enthusiastically appreciated by wire manufacturers. A smaller furnace of 25 kw. rating with pot 3 ft. long by 18 in. wide by 18 in. deep is used at temperatures of 1000° F. to 1800° F. for annealing gold, brass, nickel, heat treating aluminum alloys and tempering alloy steels from 275 to 1200° F. The short cycles for these operations are almost unbelievable to the technician and quite unbelievable to the practical old-timer. Some of the non-ferrous alloys handled in coils are in the bath only a few seconds for process annealing.

ESTIMATE HOW MUCH

HOLDEN LIGHT CASE

HOLDEN LIGHT CASE CARBURIZER FROM ZERO TO .005″
Saves you from 10% to 80%
There is a reason. They are developed products not copies.

NOTE:

We are not discussing the improved heat treating result obtained with Holden Light Case. Absence of distortion, safety to operators resulting from no fumes, shortened time cycle or better hardness.

BUT . . .
DOLLARS YOU CAN SAVE

Write or wire for a HOLDEN Engineer to call on you at our expense.

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Do you pay—
11¢
15¢
16¢
17¢
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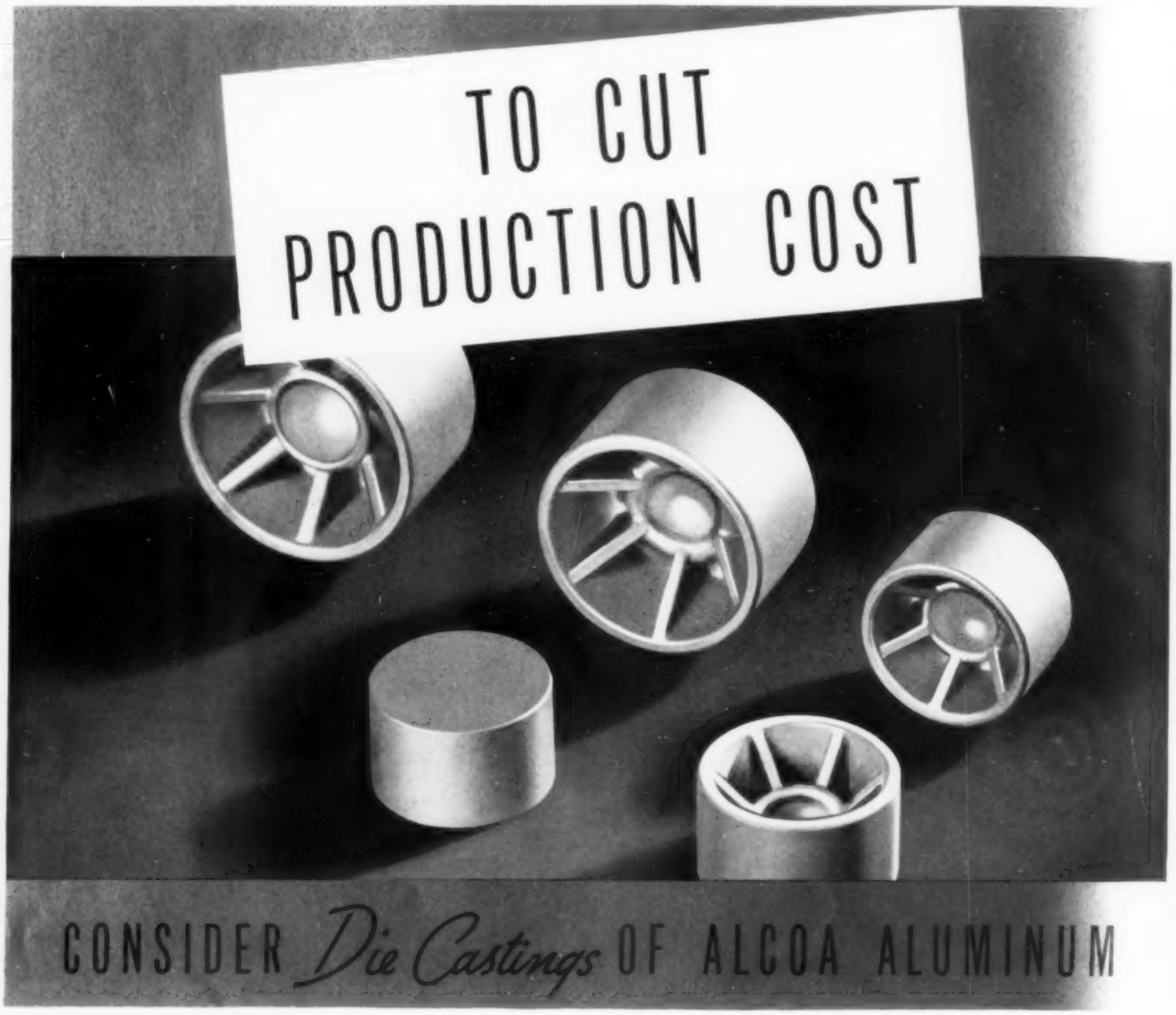
. . or more per pound of bath purchased

Figure your own saving based on this net cost per pound of steel and then let a HOLDEN Engineer tell you why and how.

Engineers at Boston—New York—Philadelphia—Buffalo—Cleveland—Detroit—St. Louis—Chicago—Milwaukee.

A.F. HOLDEN COMPANY

NEW HAVEN, CONNECTICUT



CONSIDER *Die Castings* OF ALCOA ALUMINUM

● These automotive brake pistons have to be right two ways — strong and accurate, so they'll work when they're needed — yet low in cost, to fit the remarkable economy of automobile production.

To meet requirements so rigid, die castings of Alcoa Aluminum are a logical choice. The process is fundamentally economical for quantity production, because finishing cost is reduced to a minimum. Close tolerances cut the amount of machining required. Lugs, bosses, identification marks, and special contours may be cast integral, simplifying assembly. An excellent surface is obtained. High physical characteristics peculiar to die-casting result from the quick chilling and even grain of the metal. Dimensions of Aluminum die castings are permanent, there is no "growth."

Can these typical characteristics of Alcoa Aluminum die castings save you money? Analyse your product, looking particularly for parts that move and should be light, for parts that must conduct heat, for parts that are subject to corrosion. There are several special alloys of Alcoa Aluminum to fit requirements for various physical properties in die castings, and our casting facilities make volume production under close supervision available at reasonable cost. Write for complete information. ALUMINUM COMPANY OF AMERICA, 2101 Gulf Building, Pittsburgh, Pennsylvania.

ALCOA ALUMINUM

Go these parts of versatile ALCOA *Free-Cutting* SCREW MACHINE STOCK

● Right now an ordinary dry-cell is working for you, in a bell, a buzzer, an instrument, an emergency light — any one of a thousand applications around your home, your shop, your office.

Twins of that dry-cell are working equally well, at serious jobs, at the far ends of the earth. In the Antarctic, at outposts nearest the North Pole, in the steaming tropics, in the salty mists of the high seas, in the remote orient, they do their jobs well.

Under those varied conditions you'll find EVEREADY cells, with the all-important binding-posts fitted with bright little knurls made of Alcoa Aluminum. Aluminum knurls stay bright, clean, attractive, and workable. Widely differing conditions do not impair their value because Aluminum resists corrosion.

Alcoa Aluminum Free-Cutting Screw Machine stock is the big news of the automatic machine industry. Try it, if you need low cost, or resistance to corrosion, or lightness, or attractive appearance. These advantages cost nothing extra. The bright finish on these knurls indicates that chip sizes are small, that no long turnings foul tools or hamper production. The stock is really *free-cutting;* tool speed is high and tool wear is decreased.

Material cost is surprisingly low, because Aluminum stock weighs only one-third as much, hence gives three times the parts per pound.

Ask us for samples, so you can see what Alcoa Aluminum Free Cutting stock will do for you. There is no obligation. ALUMINUM COMPANY OF AMERICA, 2101 Gulf Building, Pittsburgh, Pennsylvania.

ALCOA ALUMINUM

Faster Cutting

Money saved on every one of these jobs by faster cutting — cleaner machining Carpenter Stainless! The special non-galling and non-seizing properties of this Free Machining Stainless Steel keep the chips from sticking to the tools. Clean machining also means lower finishing costs. Are you saving all that you can on Stainless parts?

Carpenter STAINLESS

Cleaner Machining

this Stainless Steel will do the job Easier!

When the nose of the tool bites into a bar of Carpenter Stainless you can almost "feel" the difference. The chips fall cleaner and faster and the finish is finer and smoother. The easier cutting means less heat, longer tool life, increased output, lower Stainless costs.

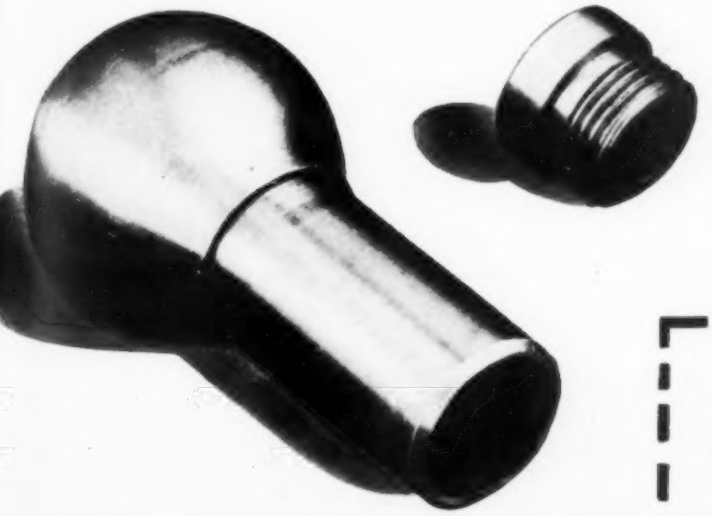
With Carpenter Stainless No. 5 — a 14% chrome iron—you can give your product all the advantages of Stainless Steel with the machining economy of ordinary screw stock.

For those parts that demand maximum corrosion resistance—Carpenter Stainless No. 8 —an 18-8 chrome nickel steel—holds down machining costs. Selenium, a recent Carpenter development, makes this tough steel freely machineable at 60% to 70% of the speed of ordinary screw stock.

And in actual service, these Carpenter Stainless Steels work more freely on metal-to-metal contacts and are less likely to scratch or gall.

If you are using Stainless Bar stock—find out how much easier you can do the job with Carpenter Free Machining Stainless Steel. And if you have stayed away from Stainless because of cost or working difficulties — remember Carpenter Stainless has licked many an "impossible" job. Try it!

The Carpenter Steel Company, Reading, Pa.



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Carpenter Stainless Steel is supplied to meet U. S. Navy, Aeronautical and Army specifications. Just tell us what specifications you have to meet.

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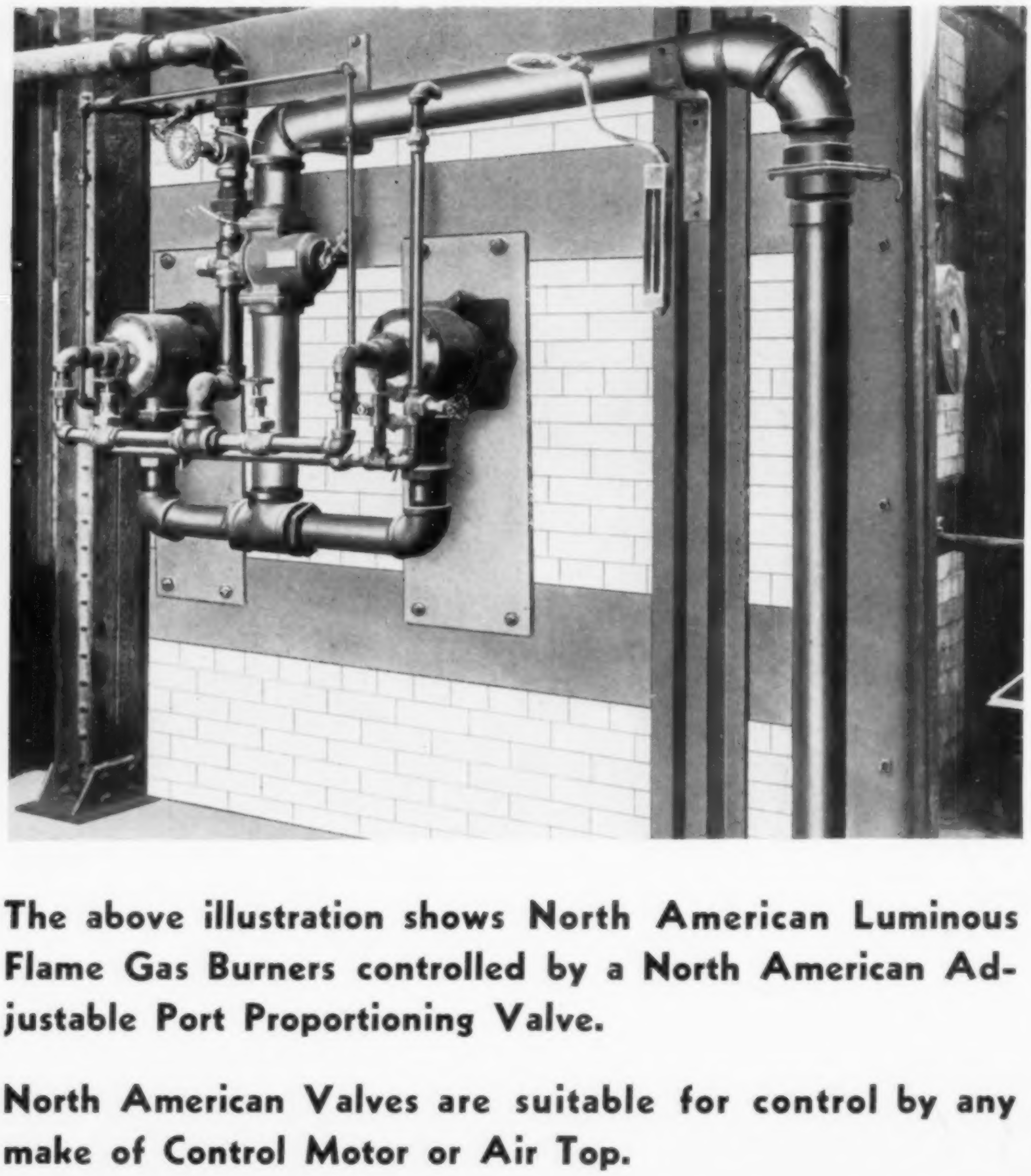
STEELS

Heat Treat with Gas

CONTROLLED LUMINOUS FLAME BURNER FOR MORE UNIFORM HEATING



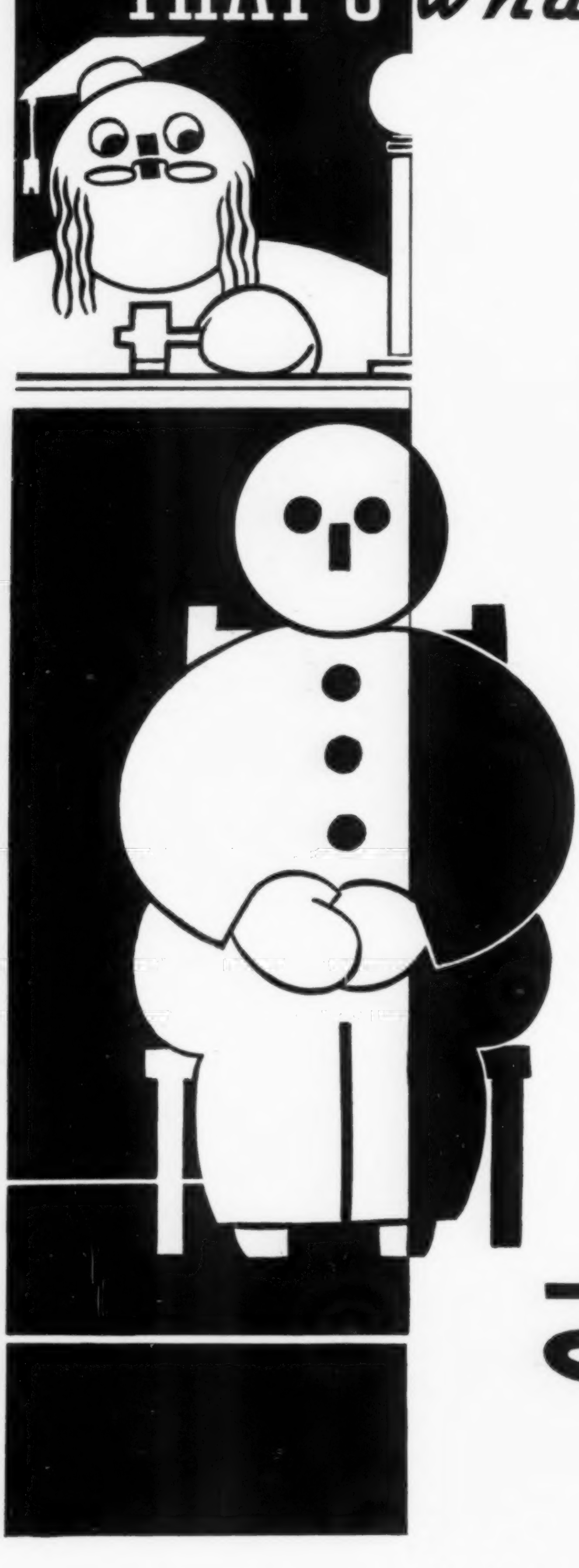
The above illustration shows North American Luminous Flame Gas Burners controlled by a North American Adjustable Port Proportioning Valve.

North American Valves are suitable for control by any make of Control Motor or Air Top.

By North American

THE NORTH AMERICAN MANUFACTURING CO. • CLEVELAND, O.
Manufacturers of Combustion Equipment

THAT'S *what you think*



THAT sounds a bit smart-aleck, but of course we don't mean it that way. We just want to raise a question in your mind—

If you have checked your thermocouple and meter and found them correct—it's easy to think that your temperature reading is O.K., too. In fact, however, your leads may be a source of considerable error..... Sometimes "compensating leads" are used with Chromel-Alumel Couples. Where these two join in the couple-connector, they form two thermo-electric junctions, which are supposed to create equal and opposite E.M.F.'s that cancel each other. They practically do cancel at low temperatures. But as the thermocouple handle gets hot, (and often it does get very hot), a serious error is likely to be introduced.... Companies having large installations more and more recognize this, and are installing Chromel-Alumel Leads for their Chromel-Alumel Couples. Thus, leads and couple are of the same materials, and the above chance of error is eliminated.

★ ★

For a technical presentation of this subject, send for Folder-GP, which you'll find easily understandable . . . Hoskins Manufacturing Co., Detroit, Michigan.

Chromel

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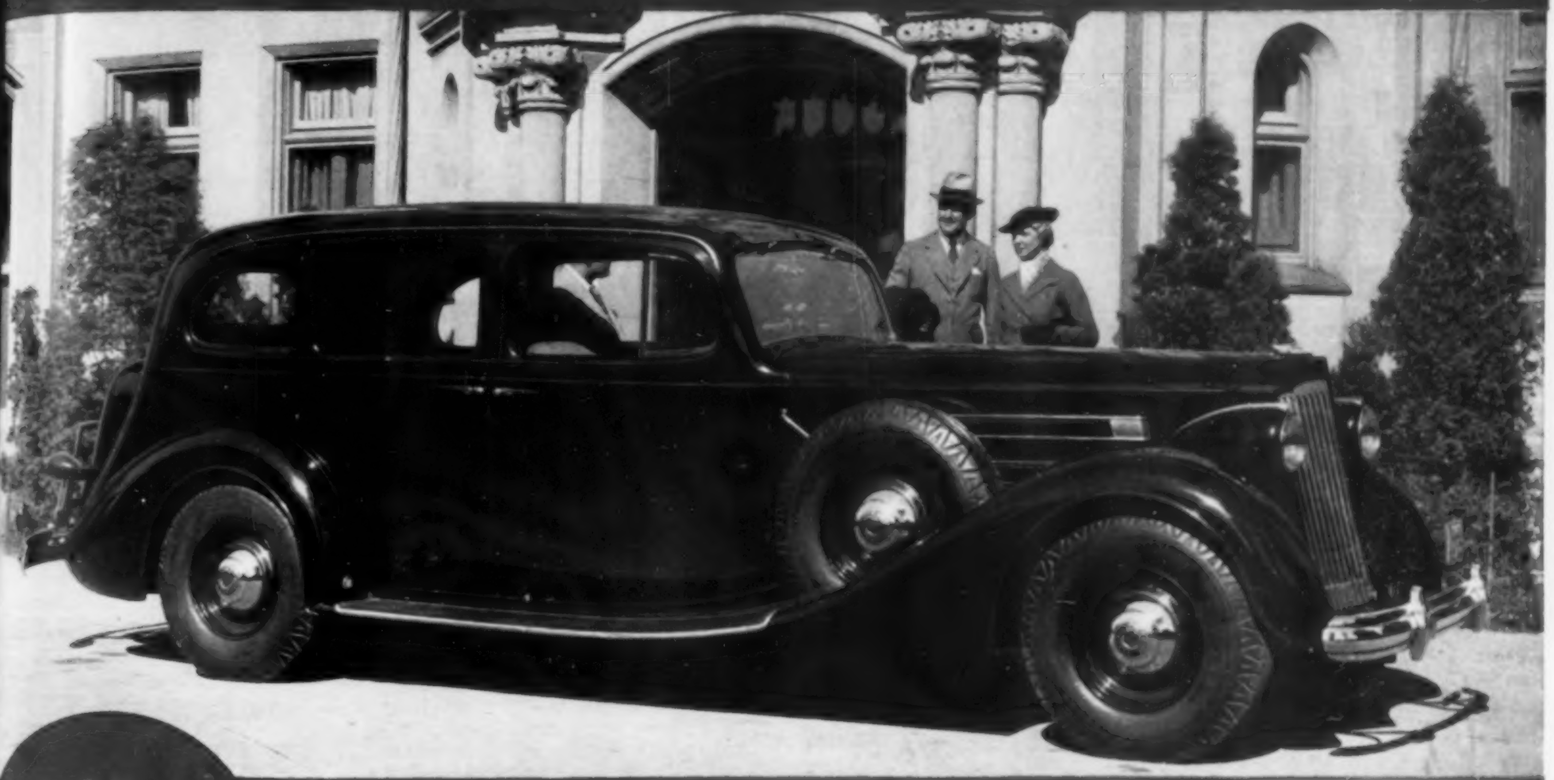
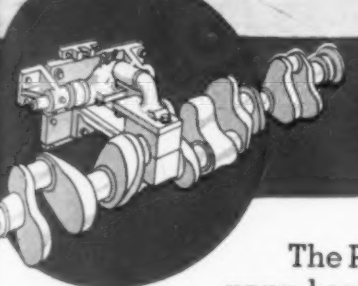
CHROMEL-ALUMEL

LEADS AND COUPLES

1937 PACKARD TWELVE HAS TOCCO-HARDENED CRANKSHAFT



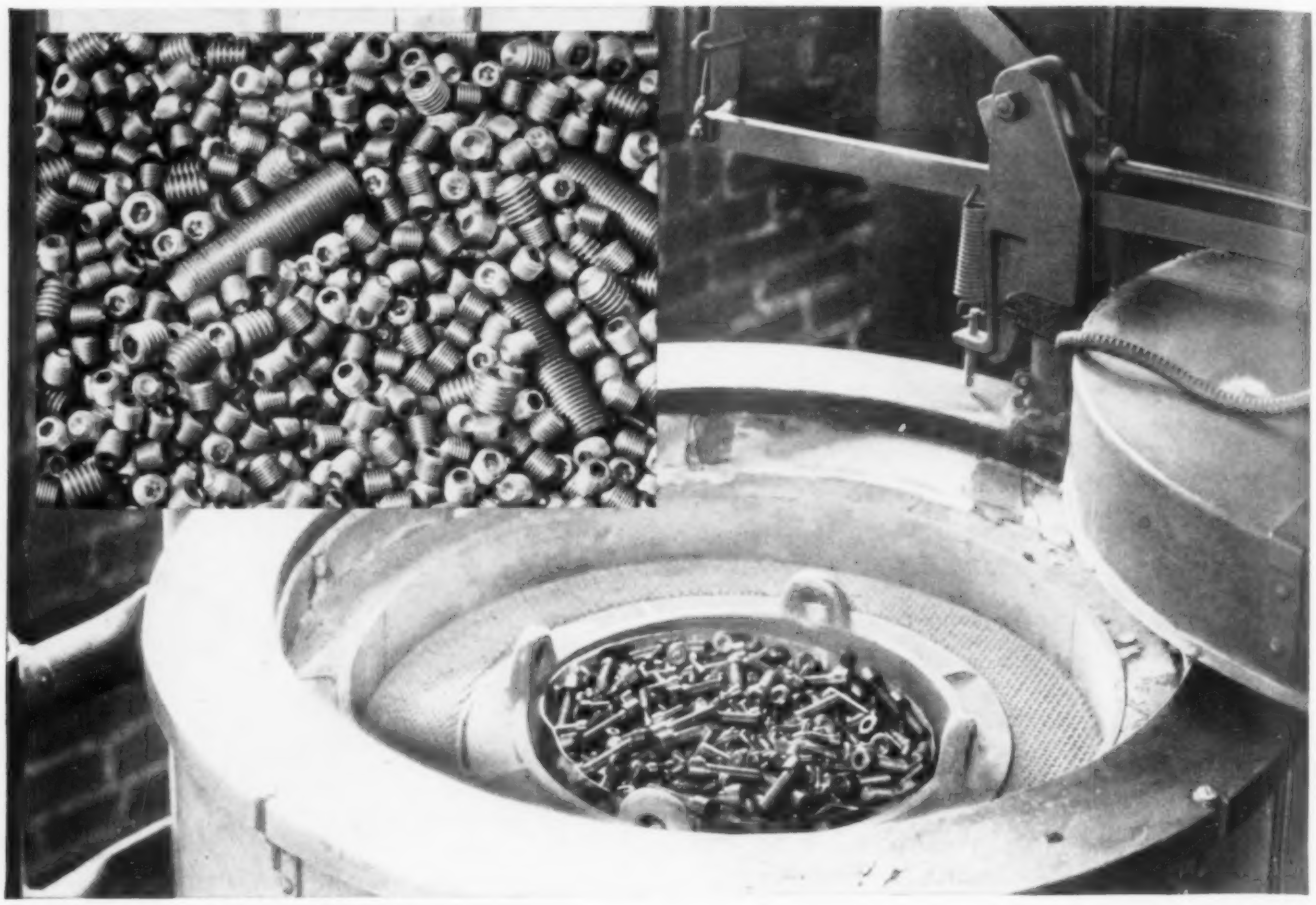


The advanced 1937 Packard Twelve—one of the world's leading automobiles—is mechanically far ahead of any car that has ever borne that distinguished name. Its V-12 engine, like the new 1937 Packard Super-Eight, has a TOCCO-hardened crankshaft—a superlative endorsement of the TOCCO PROCESS.

The Packard Motor Car Company has adopted TOCCO-hardened crankshafts for the engines of its finest 1937 cars—the Packard Twelve and the Packard Super-Eight. These new, deluxe cars, listing at the factory from $2,335 to $3,420 and up, represent the last word in Packard's experienced engineering—the best cars that money can buy! In them nothing has been overlooked which will help give "the Man Who Owns One" a superlative measure of luxurious transportation, long, trouble-free engine life and economical service. Packard engineers say that the TOCCO-hardened crankshafts in these fine passenger-car engines will give Packard owners not only longer-lived bearings but more efficient operation and lower oil and other maintenance costs. Undoubtedly Packard, which has pioneered so many engineering advances, is but the first of a long list of passenger-car manufacturers who by adopting TOCCO-hardened crankshafts will give their owners improved engines, smoother power and lowered costs.

A MASTERPIECE OF ENGINEERING

The Packard Twelve-cylinder engine is looked upon as one of the world's leading power plants. All Packard Twelve and Super-Eight engines now have TOCCO-hardened shafts.



Uniformity ...PROTECTED BY HOMO TEMPERING

Because the physical qualities of set-screws must be rather exactly balanced, precise tempering is vital. Enough draw must be conceded to prevent breakage, yet enough strength retained to foil the husky who slips a pipe over his set-wrench handle.

The Mac-it Parts Company finds that Homo forced-convection tempering gives the uniform, controlled heat that solves this tempering problem. They pre-determine both temperature and time of draw, and set the Recording Controller so that tempering is automatically done just as they want it. Skill and experience are concentrated on deciding what temperatures are needed—rather than on watching the furnace to make it hold them. And the Homo record of each batch helps the heat-treater apply his experience to best advantage on succeeding batches. As a result, tempering is a solved problem in this plant. Other plants can enjoy the same advantages; details on request.

J-625B(3)

LEEDS & NORTHRUP COMPANY
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S-75

AFTER 10 MONTHS

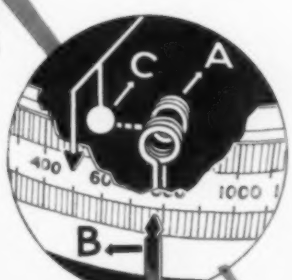
RADIO PRINCIPLE

SIMPLICITY REVOLUTIONIZES CONTROL INSTRUMENTS

With so vastly different a principle and advanced degree of constant maintenance-free performance and accuracy, the Wheelco CAPACITROL has completely astounded industry and bewildered competition. The reasons are remarkably simple.

- Extreme simplicity of operating design dictates a new low in initial control instrument cost — with an advanced standard of performance.
- The complete absence of cams, gears, motors and other moving and easily wearing parts assures a constant unvarying accuracy in control — unknown in the past.
- The *Radio Principle* is absolutely void of direct contacts and therefore will not stick or otherwise cause production delays and costly damage to furnace or load.
- CAPACITROL incorporates the same minute selectivity found in the modern radio sets and is dependably operated with the same ease.

CAPACITROL'S *Radio Principle* betters the standard of performance of that of the highest priced instrument on the market. Further information and engineering data will be furnished promptly upon request.



RADIO PRINCIPLE SIMPLICITY

A current of given wave length flows between the two coils "A" shown in the accompanying illustration (which are attached to and move with temperature limit set pointer "B"). Flag "C", which is a part of heat indicator enters between coils "A", causing a sharp drop in their inductance, thereby changing the wave length of a Radio Tubz Oscillator which operates a relay.

WHEELCO INSTRUMENTS CO.

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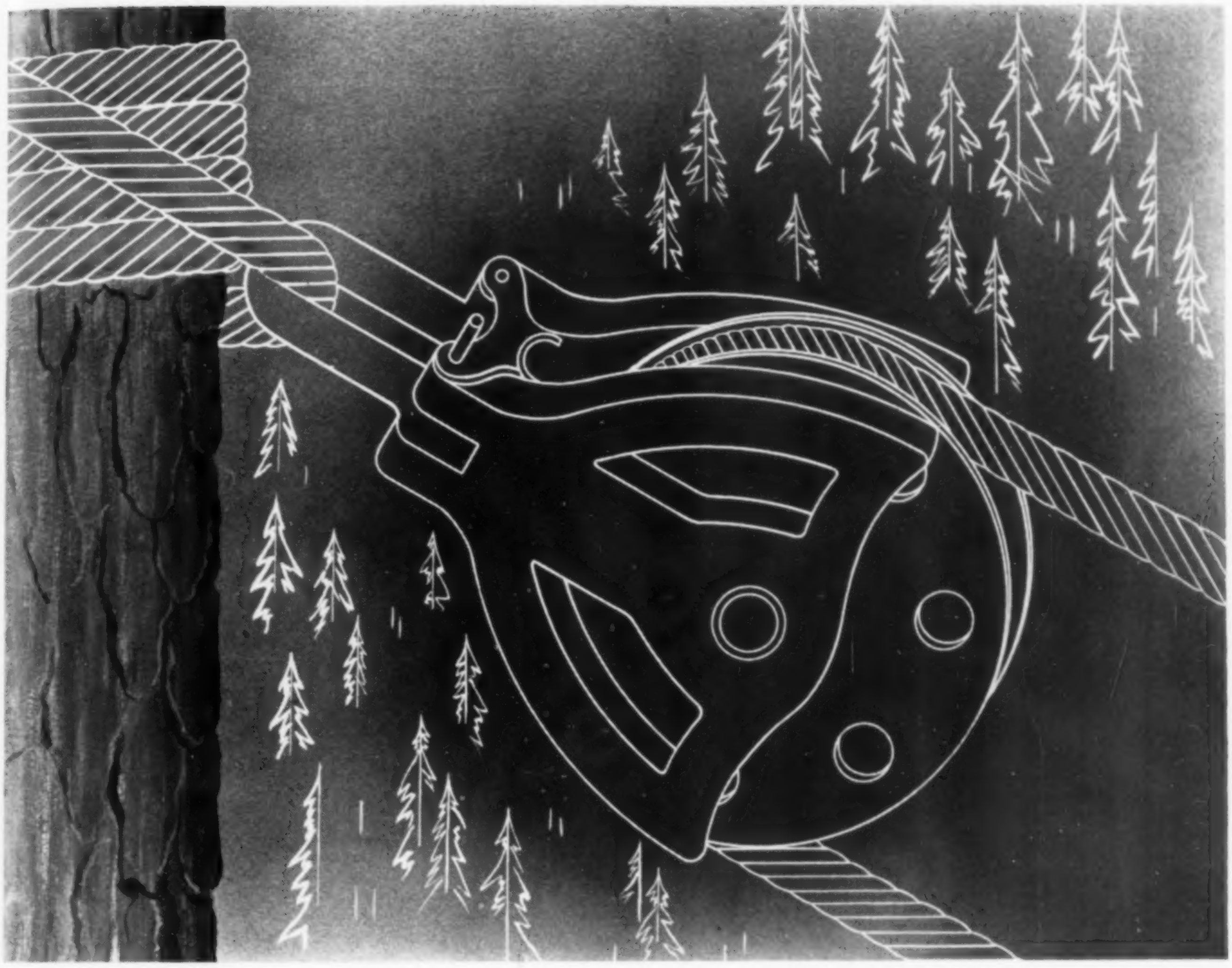

MOLY steel's greater strength means less weight—easier handling

WHEN operating equipment has to be handled by man-power, the importance of light weight through the use of the strongest possible material comes home with telling effect. Logging blocks, for example. Ask any rigger what a back-breaking job it is to tote them aloft. Think, too, of the abuse they get. . . . Dropped from great heights, battered and banged around, exposed to weather—it's a hard life they lead.

By making side frames and sheaves out of 2% Nickel-0.40% Moly steel, the weight of logging blocks can be reduced one-third to one-half—without sacrifice of strength. Similar foresight in the construction of other forms of industrial equipment can lead to corresponding savings in time, labor, wear, depreciation.

What do you make or use that would gain through lighter weight, higher strength, greater resistance to impact, abrasion, creep, corrosion? Look into Moly and its many-sided qualities for improving any steel or iron—whether plain or otherwise alloyed. Our helpful technical book, "Molybdenum," goes into the subject at considerable length. Yours for the asking—as is also our periodical news-sheet, "The Moly Matrix." If interested in some particular ferrous problem, our laboratory facilities are at your disposal.

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PRODUCERS OF FERRO-MOLYBDENUM, CALCIUM MOLYBDATE AND MOLYBDENUM TRIOXIDE

MOLY CLIMAX **Mo-lyb-den-um**

CUTS COSTS

CREATES SALES

PERSONALS

Gerald R. Brophy, formerly with General Electric Co., Schenectady, has joined the laboratory of International Nickel Co. at Bayonne, N. J.

P. J. Graber has joined the sales department of Bethlehem Steel Co.

John R. Houston has become associated with the metallurgical department, Chicago district, Carnegie-Illinois Steel Corp.

C. T. Williamsen, who joined the sales department of Bantam Ball Bearing Co. last May, has now been made territorial representative in southern Indiana and southern Ohio for the Torrington Co., of which the Bantam Co. is a subsidiary.

Russell F. Marande has accepted a position as metallurgist for the McGean Chemical Co., Cleveland.

John A. Mathews, Jr. has been transferred from the New York to the New Haven branch of Crucible Steel Co. of America.

Robert W. Simmons is employed as a student engineer with the General Electric Co. at Schenectady.

R. S. Cochran, formerly metallurgist for Surface Combustion Corp., is now superintendent of Magnetic Pigment Co. of Monmouth Junction, N. J.

W. Glenn Heberling, previously industrial engineer for Columbia Steel Co., is now safety engineer for State Compensation Insurance Co., Los Angeles.

Railway & Power Engineering Corp., Ltd., A. F. McLachlin, vice-president, has been appointed exclusive distributors for Crucible Steel Co. of Canada.

James T. Gow has joined the staff of Battelle Memorial Institute, Columbus, Ohio.

P. C. Badgley has been transferred by the Leeds & Northrup Co. to open a new district office at Hartford, Conn.

E. L. Knapp has taken a position with Bethlehem Steel Co., Lackawana mill, and will be located in Detroit.

Paul S. Lane has been promoted to metallurgical research engineer by the Koppers Co.

H. B. Wishart has finished his work at the Materials Testing Laboratory, University of Illinois, and has joined the metallurgical laboratory of Carnegie-Illinois Steel Corp., at Gary, Ind.

W. M. Lindsey, formerly chief metallurgist of Washburn Wire Co., Phillipsdale, R. I., has been made chief metallurgist of Carnegie-Illinois Steel Corp. South Works, Chicago.

PERSONALS

Archibald Jones, Jr. ⊕ is now employed by Oxweld Acetylene Co., Newark, N. J.

Ernest R. Howard ⊕, mechanical engineer for H. A. Wilson Co., Newark, N. J., was married on Sept. 6 to Miss Clarion Leatart of Pasadena, Calif.

Harold N. Jameson ⊕ has been appointed chief metallurgist and superintendent of the heat treating department of the National Erie Corp., Erie, Pa.

R. H. Sonneborn has been named assistant manager of sales, pipe division, Republic Steel Corp., Cleveland.

Morris Asimow ⊕ is now living in Chicago as metallurgist with Carnegie-Illinois Steel Corp.

Edward J. Hanley has been appointed secretary of Allegheny Steel Co. succeeding **Frank H. Stephens**, who has resigned but continues as a vice-president and treasurer.

Grant Goodwin ⊕ is now associated with the Lindberg Engineering Co. as district manager of the Indiana and southern Illinois territory, with headquarters in Indianapolis.

John L. Young ⊕ has been appointed manager of machinery sales, and **Joseph Kinney, Jr.** assistant manager of machinery sales for United Engineering and Foundry Co., Pittsburgh.

D. L. Mathias has joined the staff of Metal & Thermit Corp., New York, in the capacity of research engineer.

George H. Weiler has become associated with the Vanadium Corp. of America as manager, eastern railroad division, with headquarters in New York City.

W. W. Williams, formerly general sales manager, has been made general manager of the Babcock & Wilcox Tube Co., Beaver Falls, Pa. **T. F. Thornton**, sales manager of the Detroit district, is now general sales manager.

B. E. Sivyer, Jr. has been appointed branch manager of the Chain Belt Co.'s San Francisco office.

E. T. Slackford has been appointed advertising manager of the Harnischfeger Corp., Milwaukee.

John Harding ⊕ has resigned as chief metallurgist for Atlas Drop Forge Co., Lansing, Mich., to join the Metallurgical Department, Carnegie-Illinois Steel Corp., Chicago district.

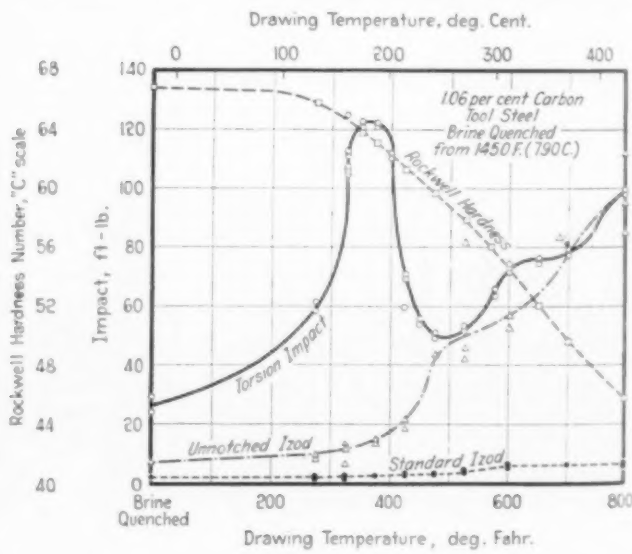
Kelvin Sproule ⊕ has obtained leave of absence from the International Nickel Co. of Canada to do post-graduate work in metallurgy at McGill University on the Dawson Fellowship.

TORSION IMPACT

(Cont. from page 55) forces are overcome and the material breaks or splits with an absorption of energy hardly greater than that required for elastic deformation.

On the other hand, tough fracture occurs if the yield point (and permanent set) is reached first during rapid loading; the metal "self-hardens," or increases in strength while the cold work of deformation grows. Fracture finally occurs with a very considerable absorption of energy. The relation between these two limiting values of the stress depends on the structural state of the metal, the testing temperature, the shape of the specimen, the rate of deformation and the state of the stress.

In the case under examination the last factor is of controlling importance. Brittle fracture does, in fact, occur as the result of *normal* (tensile) stress, while permanent deformation (slip) is caused by *shear* stress. In the case of uni-axial stress such as occurs in the outer fibers of a bar subjected to bending, the maximum shearing stresses are one-half of the normal, while in the case of pure shear these two components are equal, and the maximum normal stresses act in planes at an angle of 45°. In torsion, therefore, the ratio of shearing to normal stress is double that during stretching or bending; simultaneously the tendency toward a tough rather than *(Continued on page 80)*



Relation Between Impact, Hardness and Draw Temperature of Carbon Tool Steel (Luerssen and Greene)

TORSION IMPACT

(Starts on page 55) a brittle fracture increases considerably. It should also be possible to find in Luerssen and Greene's tests conditions in which the specimen will give a tough fracture under torsion and a brittle one under bending.

In the original publication photographs of fractured test pieces are given and from them we find that in quenched specimens drawn up to 275° F. the surface of rupture is at about 45° to the axis, indicating that the fracture was started by normal and not shear stresses. Consequently the fracture will be typical of a brittle rupture with negligible absorption of energy. In the temperature interval from 275 to 375° F. the fracture gradually changes from oblique to perpendicular while the work of deformation rises considerably. This indicates that the brittle fracture passes over into the tough type caused by shear stress as a result of the steadily increasing brittle strength and decreasing yield point. (The decrease in the latter was observed by Emmons in his static torsion tests; it also appears in the lowered hardness.)

At 375° F. the fracture is completely tough (flat and square). At higher temperatures the second part of the diagram, which corresponds, according to Luerssen and Greene, to the steady decomposition of the austenite, represents the change of the energy required for a tough fracture of this decreasing amount of residual austenite (plus, probably, changes in the internal stress in the sample).

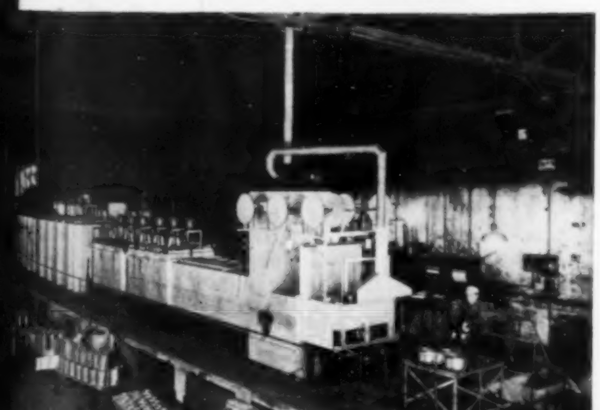
Turning now to the results on impact tests of un-notched bars, we find first of all a typical brittleness with scarcely any increase in the work of deformation up to 400° F., after which the curve rises to 475° F. Up to this temperature the curves for torsion and bending tests have no relationship but above it they agree.

It must be recognized that up to 400° F. the brittle fracture by bending and small absorption of energy is due to the low "brittle strength" of the steel. The transition to the tough condition observed in the torsion tests is absent, on account of the low ratio of the shear to the normal stress (50%). At drawing temperatures above 400° F. the yield point has decreased and the brittle strength increased sufficiently for the transition to the tough state to start, and the transition is complete at 475° F. This transition is accompanied by a (Ends on page 84)

AN DRY BRIGHT *Uniformly* DUCTILE

RMANCE

FOR NON-FERROUS PRODUCTS
WITH WESTINGHOUSE ELECTRIC FURNACES



A uniformly ductile product . . . delivered clean . . . dry . . and bright. These are four advantages that makers of non-ferrous products can obtain when they anneal in Westinghouse atmosphere-controlled electric furnaces.

For many years Westinghouse has been making refinements in furnace design for more efficient. . . . more economical operation on every type of heat-treating application. Backed by vast resources and unexcelled research facilities Westinghouse heat-treating engineers have blazed the trail to better . . . more uniform annealing of non-ferrous products.

Investigate the advantages of Westinghouse electric furnaces. There's a type for almost every application and an experienced staff of trained engineers to help you select the furnace that *best* fits your needs. Let one of them study your requirements and make recommendations. No obligation, of course. J 10011

★★★★ Return recuperative pusher type furnace annealing copper strip in coils.

WESTINGHOUSE 1886 W 1936 GOLDEN JUBILEE

Westinghouse

TORSION IMPACT

(Starts on page 55) steady increase in the permanent set and therefore by an increase in the energy absorbed, which quite mechanically masks the decrease in toughness dependent on the changes in the microstructure in this temperature range and which can only be detected in torsion tests (when the type of fracture remains unaltered).

Above 475° F. both types of test put the metal in the same tough state and therefore give similar results. Thus we see that the characteristic peak at 350° in Luerssen and Greene's diagram is an attribute not of *impact* but of *torsion.*

Since torsion is a favorable working regime for a tool, it is necessary to test it by bending if it is to be used in bending. It is not surprising that the hardness gives results differing from both impact tests, since the material is not ruptured and therefore the question of strength (which is the main factor in determining the energy absorbed) does not enter.

N. N. Davidenkow

INCLUSIONS

(Cont. from page 51) solubility of calcium carbide in blast furnace slag and electric furnace slag—carbides and nitrides of dense metals are frankly metallic. Iron nitrides and carbides dissolve in molten metal and form solid solutions of great technical importance.

More generally, the compounds formed by carbon and nitrogen (and also hydrogen and boron) with the transition metals have a metallic character not found with the other metals and the metalloids. It is not clear why titanium nitrides should be separated in this respect from the others, as some metallurgists have suggested. Moreover, certain refractory nitrides and carbides (of tungsten, zirconium, vanadium and titanium) tend to form atomic systems of very high hardness; by extrapolation the carbides of boron and of silicon and the diamond type of carbon belong in this category. Finally, a study of the constituents of steel demonstrates the similarity between carbides and nitrides; this was particularly evident to us in the study of the iron-chromium alloys.

From what we have just said, we may conclude that:

1. For the same cation, the metallic character of compounds increases in the following order:

$O \rightarrow S \rightarrow N$ and C (likewise P and B)

2. For the same anion (O, S, N or C) the metallic character appears to increase in compounds with elements in the following order:

Alkalis and alkaline earths $\rightarrow$ Mg and Al $\rightarrow$ Mn $\rightarrow$ Fe, Co, Ni $\rightarrow$ Cu

Now if we wish to define inclusions as "non-metallic substances," we bump into the same difficulties that are always met in attempting to separate a continuous or progressive series. Indeed, after much consideration it hardly seems possible to formulate a general definition applying to all inclusions in all metals. In limiting ourselves to inclusions in iron and similar metals, we would be tempted to make the following arbitrary and conventional division wherein the idea of impurity or harmful element is entirely relative and variable:

Inclusions in steel are silicates, aluminates, oxides and sulphides.

Metallic constituents in steel are nitrides, carbides, borides and perhaps phosphides.

ALBERT PORTEVIN


Instantaneous
ACTION

ELECTRIC IRON

(Continued from page 51)

4. Remelting pig iron in electric furnaces of a design similar to that of normal steel furnaces, for the manufacture of high quality iron to close chemical specifications. The ever-increasing demand for iron castings of high mechanical, physical and chemical quality explains the rapid increase of foundries adopting this process. One of the main reasons for its popularity is the high modulus of elasticity obtainable in these electric castings as compared with the cupola product.

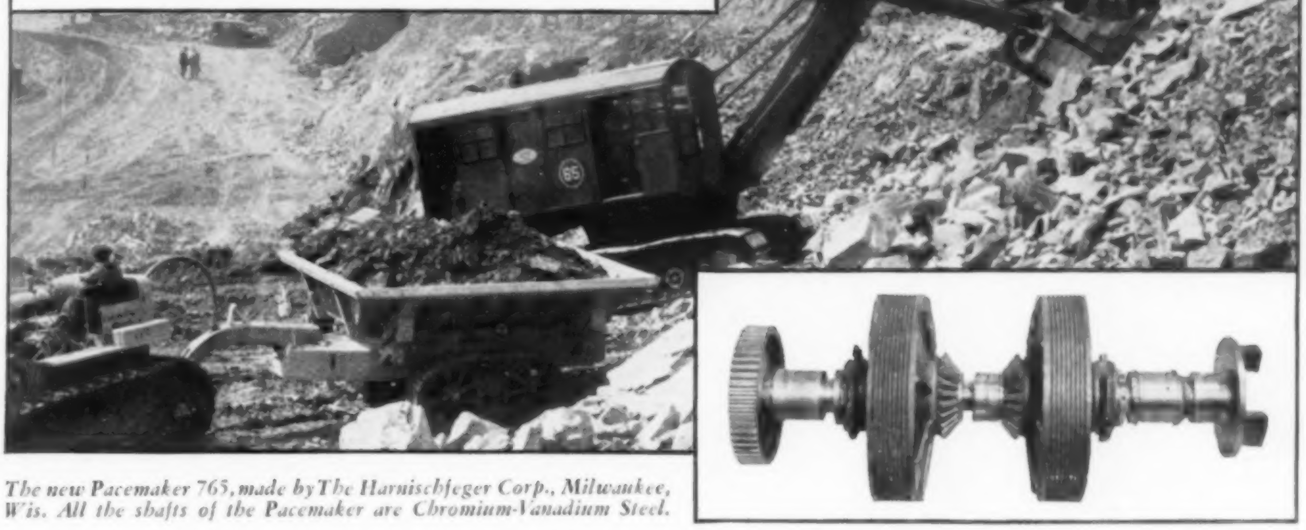
Again, the peculiar conditions under which this process is applied in different European countries vary considerably according to local conditions. In France and Germany there is a tendency to treat liquid iron from the blast furnace in large electric furnaces for its superheating, refining, desulphurizing and adjusting its chemical composition. Iron thus refined is cast into pigs and sold to foundries for remelting in the cupola or revolving furnace, or as an addition to the charge to improve the quality of other cheaper irons. These electrically refined irons are generally low in carbon (2.5%), sulphur (0.05% max.), phosphorus (0.08% max.) and silicon (1.0 to 1.5%), while their manganese content is usually higher (0.9 to 1.3%) than in ordinary foundry iron.

In other countries like Italy, a cold charge of ordinary blast furnace pig iron is remelted and refined by the foundry itself in electric furnaces of proper capacities (generally smaller than in the preceding case) and cast in molds in the usual way.

The economic advantage of this process, requiring more electric power, depends on the ratio between the cost of power and the cost of coke, while its technical superiority (from the point of view of exact composition, purity, proper casting temperature, and so on) is evident. Sometimes where the technical superiority of the products obtained by the last process has a deciding importance, the economic obstacle of costly power is partly removed by melting the iron in a cupola, and limiting the action of the electric furnace to overheating, refining and adjusting the chemical composition. However, this interesting duplex process has been so far very seldom used in Italy.

Federico Giolitti

DON'T WORRY ABOUT THE SHAFTS...



The new Pacemaker 765, made by The Harnischfeger Corp., Milwaukee, Wis. All the shafts of the Pacemaker are Chromium-Vanadium Steel.

They Are Chromium-Vanadium Steel!

Watch one of those new "Pacemaker 765" Shovels at work and you marvel at its speed and ruggedness.

Quick starts . . . sudden stops . . . violent shakes of the dipper . . . heavy loads . . . speedy lifts — you begin to wonder whether the shovel, massive as it is, will stand the gaff. But, don't worry about the Pacemaker shafts — *all* the principal ones of this well-known shovel — the two drum shafts, jack shaft, intermediate shaft, vertical propeller shaft, horizontal propel shaft — are Chromium-Vanadium Steel.

Are there parts of your products in which better steels would safeguard operation and improve performance? The Metallurgical Staff of the Vanadium Corporation of America will gladly help you select a steel or steels that will meet your requirements.

•

VANADIUM CORPORATION OF AMERICA
420 LEXINGTON AVENUE, NEW YORK, N. Y.
Plants at Bridgeville, Pa., and Niagara Falls, N. Y.
Research and Development Laboratories, Bridgeville, Pa.

Vanadium Steels

METALS VANCORAM ALLOYS

FERRO ALLOYS
of vanadium, silicon, chromium, and titanium, produced by the Vanadium Corporation of America, are used by steel makers in the production of high-quality steels.

FOR STRENGTH · TOUGHNESS · DURABILITY

"If you can't sell that idea to any ten year old child--they'll have to burn down the school-house to get him out of the third grade"

—Remarked a prominent Executive

HE referred to the Harris Hinged Tray, Patented, exclusive product of General Alloys Company. For use in pusher, and conveyor type, furnaces for all heat treating operations, these trays are replacing solid trays, on the largest installations, and wherever users are informed of progress.

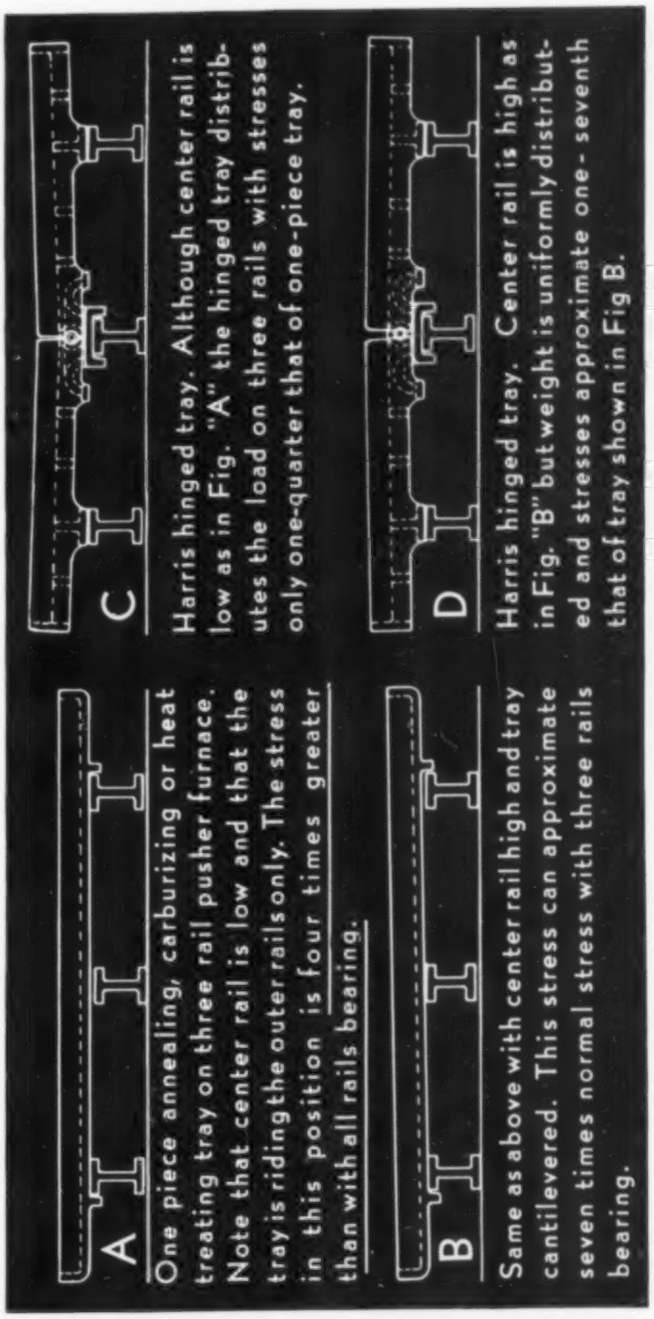
OBVIOUS REASONS: They Are LIGHTER,—last LONGER,—cost FAR LESS per heat-hour of service, SAVE Fuel, Handling, fixed charges. They frequently save heating time. *Their first cost is generally lower.*

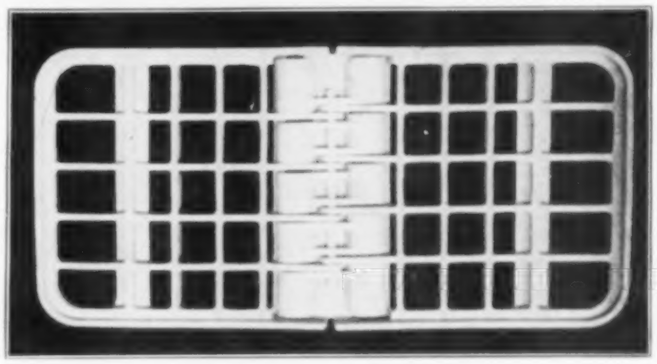
IF you were going to build a bridge span one hundred feet wide, without central support, it would take more than three times the steel than with one support in the center, cutting the unsupported span to fifty feet. This is just as true in a two car garage, or with Junior's blocks. Just "Common Horse Sense".

THIS argument sounds logical for any three rail furnace with solid trays, until you remember that the *rails vary in height and a tray must either be rigid enough to span the outer rails, or it will flex and fail from fatigue,*—WITHOUT A HINGE in the middle. (See diagram).

ON two rail furnaces recently built, from 12" to 24" spans, the users are condemned to pay for from 18 lbs. to 45 lbs. more alloy on each and every tray used, and heat and handle this extra weight for as many years as it takes them to catch up with 1934 General Alloys practice. It would take less than half the first cost saving in trays to pay for the third rail in the furnace, *and more than 50% extra tray life could be expected.* In some cases the tray savings would pay for the furnace during its life-time.

P.S. If you use, buy, sell, or build furnaces, General Alloys can serve you, for we pioneered alloy furnace mechanism, and the reputation of most furnace builders was built on X-ite and Q-Alloys equipt furnaces.





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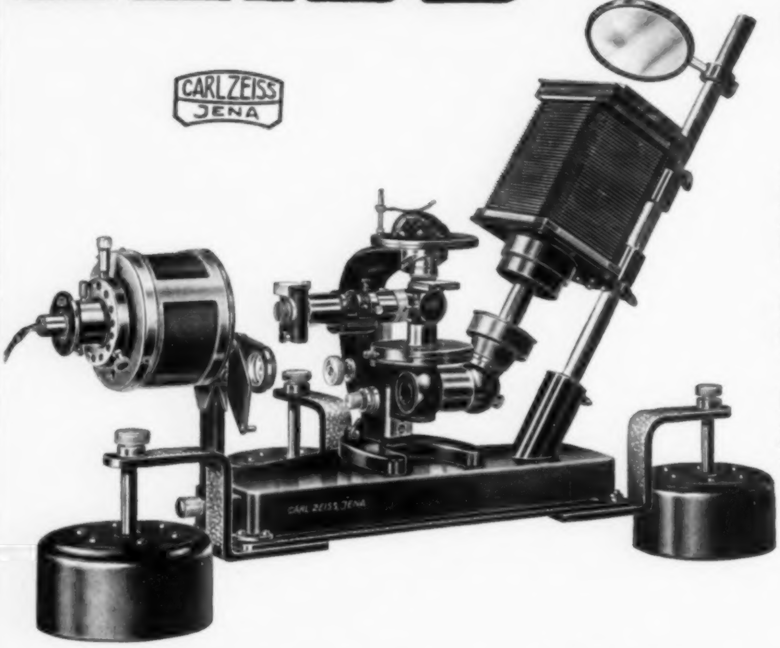

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Electrically heated Babbitt Pot manufactured by Harold E. Trent Co., Philadelphia in which Kanthal is employed as the heating element.

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Here is an application of Kanthal made by one prominent electric furnace manufacturer. He uses Kanthal because in its several forms, more compact units are possible (greater resistance being obtained with shorter wires); longer life is assured (Kanthal's high resistance rating giving greater operating economy); costs are reduced (Kanthal D, for instance, with 15% lower specific gravity produces more units per lb. of material) and corrosion factor practically eliminated (particularly where sulphurous fumes are present).

Ask us for other demonstrations where Kanthal has opened up new doors of opportunity to manufacturers of electric heating apparatus.

The C. O. Jelliff Mfg. Co.
SOUTHPORT, CONN.

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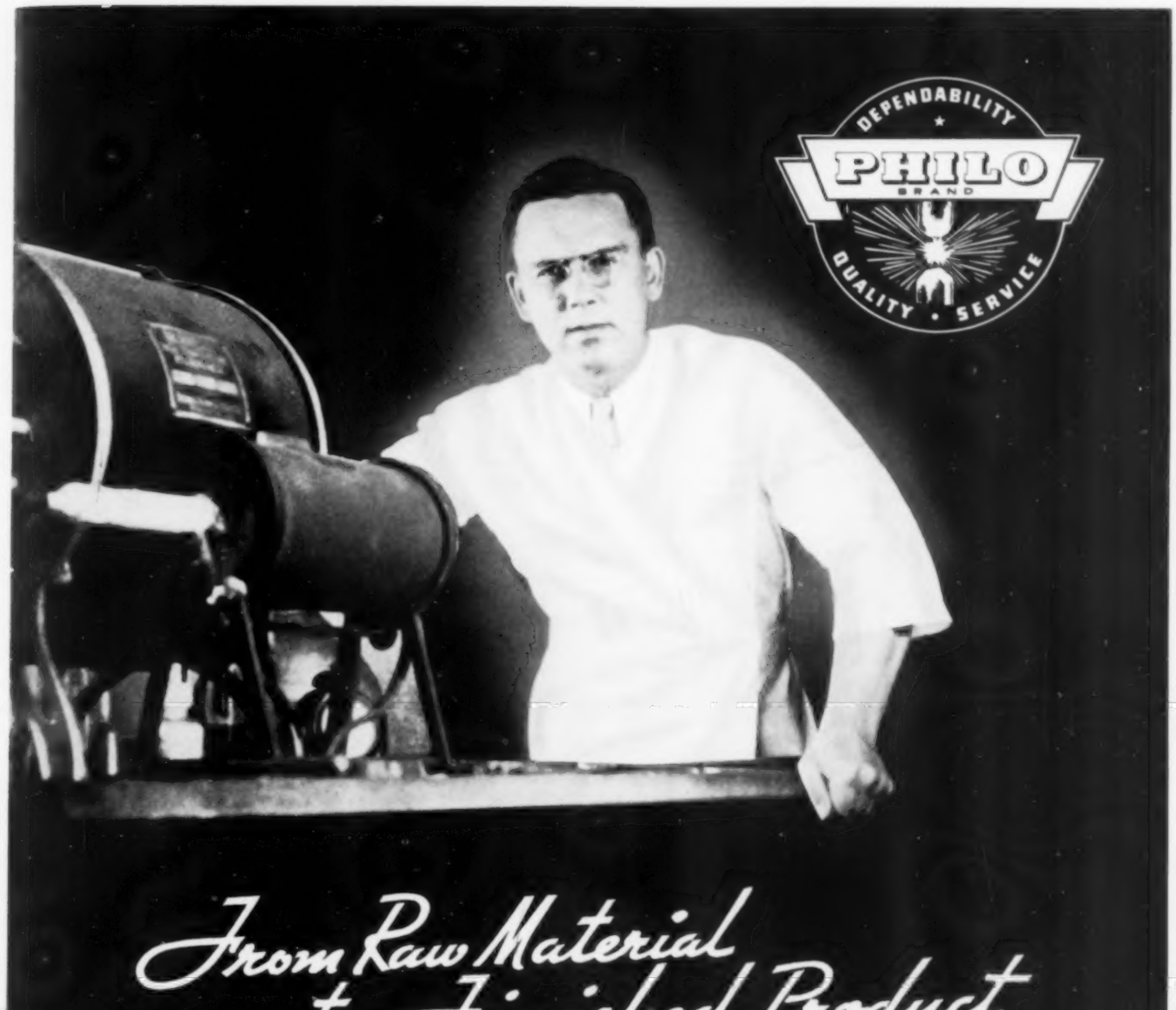
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exacting a definite standard of QUALITY
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Canton, Ohio

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Binocular Microscope

The new Bausch & Lomb wide field binocular microscope permits actual perception of length, breadth, and depth at magnifications from 7 to 150 diameters. The three different models are described in Bulletin Dy-35.

Gas Furnaces

Six bulletins on Super Blowpipes, Improved Pot Hardening Furnaces, Improved High Speed Steel Furnace, Improved Oven Furnaces, Improved Aluminum Melter, and Improved High Heat Melter, will be sent by American Gas Furnace Co. Ask for Bulletin Dy-11.

Drawing Furnace

A new convected air gas fired furnace for drawing and tempering dense loads has been announced by Despatch Oven Co. Complete details concerning its design and operation, the results obtainable, and prices are given in Bulletin Dy-123.

Compressor Data

General information on the application of blowers to gas and oil burners, and miscellaneous applications for other types of work are included in a 12-page "Turbo Compressor Data Book." Useful tables and charts are included. Spencer Turbine Co. Bulletin Dy-70.

X-Ray Examination

The application of X-ray examination and inspection to castings, welding, and food products, as well as practical X-ray crystal analysis, is completely described and strikingly illustrated in General Electric X-Ray Corp.'s new 34-page publication. Bulletin Dy-6.

New Homo Furnace

The new Homo furnace described in a bulletin issued by Leeds & Northrup provides for even tempering on a very dense load. Automatic control includes a feature that prevents overshooting. Fine tempering on extra dense loads at low cost is provided. Bulletin Mx-46.

Chain

Interesting information on chain and belt conveyors for use at high temperature may be had by sending for a new illustrated bulletin by Michigan Steel Casting Co. Bulletin Dy-84.

Bright Annealing

Electric Furnace Co. tells about their controlled atmosphere furnaces for continuous deoxidize annealing, bright normalizing and annealing ferrous and non-ferrous metals. Work comes clean, bright and dry from these furnaces. Bulletin No-30.

Laboratory Service

A new edition of "The Metal Analyist" tells about an organization established by Adolph I. Buehler specializing in the installation of metallurgical laboratories. The complete line of laboratory equipment marketed by Buehler is also catalogued. Bulletin Dy-135.

Insulating Firebrick

Complete information on the five types of insulating firebrick made by Babcock & Wilcox Co. is contained in a new booklet. The physical data, typical applications, and illustrative descriptions of lightweight constructions should interest all those concerned with furnace construction and maintenance. Bulletin Myb-75.

Forging Experience

The experience of 21 years has made National Forge and Ordnance Co. the headquarters for a host of basic electric steel products. Typical products and equipment for making them are described in a series of attractive pictorial circulars. Bulletin Dy-136.

Valveless Controllers

Dependable uniformity in feeding heavy fuel oil can be accomplished by the use of Johnston valveless automatic controllers, which use positive metering pumps. These units are described in detail in a booklet illustrated by photographs and charts. Johnston Mfg. Co. Bulletin Dy-155.

Enduro 18-8 Types

Detailed data on Enduro 18-8 and its several variations are featured in a 24-page book by Republic Steel Corp. which is radically different in layout, photography, and typographical treatment. Bulletin Dy-8.

Rotoblast

A new blast cleaning machine eliminates the need for compressed air as the abrasive driving agent. Pangborn Corporation tells how a rapidly spinning wheel propels the abrasive by controlled centrifugal force. Bulletin Ox-68.

Sheffield Steels

Wm. Jessop & Sons, Inc., have a leaflet which tells why a special anneal and a proper balancing of carbon, manganese and tungsten combine to make Sheffield Superior oil hardening steel non-distorting and easily machinable. Bulletin Jn-61.

Rustproofing

How the Detrex method of solvent degreasing provides the advantages of speed, economy, and satisfactory cleaning before all kinds of rustproofing and finishing operations is pointed out in a leaflet by Detroit Rex Products Co. Bulletin Dy-111.

Controllers

The Brown Instrument Co. has published a new catalog covering the complete line of Brown air-operated controllers. It explains in simple, non-technical language the principle of operation and contains many helpful diagrams. Bulletin Dy-3.

Portable Grinders

Norton Company tells how portable grinding and finishing equipment can be profitably used in the foundry cleaning room, in the steel mill, for fabricated metal products, in railroad and car shops, in the stone industry, and in the tool room and die shop. Bulletin Oy-88.

Kanthal

Kanthal, an alloy for electric heat developed in Sweden, is now being marketed in the United States by C. O. Jelliff Mfg. Corp. A new catalog gives full information on properties, forms available and fabrication. Bulletin Oy-78.

Pyrometer Accuracy

A thought-provoking folder of Hoskins Mfg. Company explains how the use of Chromel-Alumel for pyrometer lead-wires makes it possible to take full advantage of modern pyrometric instruments. Bulletin Ob-24.

Locomotive Steels

A comprehensive review covers specific applications, based on current practice, of various types of vanadium steels for locomotive and car construction. It contains 72 pages and is available to railway executives and engineers. Published by Vanadium Corp. of America. Bulletin Dy-27.

Forgings

The story of Heppenstall forgings is told in photographs augmented by explanatory text. Eight pages of reference tables add to the value of this book to anyone who uses steel forgings or shapes. Bulletin Mya-122.

Silmo Steel

A series of six loose-leaf pages is available from Timken Steel & Tube Co. which gives complete physical data on "Silmo," a new steel especially designed for applications where an economical combination of high temperature strength and oxidation resistance is required. Bulletin Dy-71.

Camera-Microscope

A highly efficient and up-to-date apparatus that is an ingenious combination of several instruments into one universal camera-microscope is described by Pfaltz & Bauer, Inc. in a handsomely printed booklet containing some intriguing photomicrographs. Bulletin Oy-142.

Light Case

Severe breakdown tests were run by A. F. Holden Co. to study the characteristics of Holden Light Case in relation to case penetration and the total change of chemistry of the bath. They are described, and a chart showing results is reproduced, in a folder ready for distribution. Bulletin Dy-55.

Electromet Review

A very attractive new house organ has recently made its appearance. It gives news and views of alloy steels and irons, but is mostly concerned with stainless steels. Electro Metallurgical Co. publishes it. Bulletin Ox-16.

Polishing Machine

The Guthrie-Leitz automatic polishing machine is designed to eliminate all elements of the human equation which make the hand preparation of metal specimens so undependable. Described by E. Leitz, Inc. Bulletin Jyx-47.

Nickel Publications

International Nickel Co. has a list of 62 publications on nickel and its alloys which they will supply free of charge. An order blank is attached to the list to facilitate ordering those publications of interest to you. Bulletin Sy-45.

Stainless Steel Facts

Carpenter Steel Co. offers (to manufacturers in U.S.A. only) a booklet, designed in handy file folder form, presenting a wealth of data on Carpenter stainless steels. A good reference source of material. Bulletin De-12.

New Recorder

C. J. Tagliabue Mfg. Co. announces for the first time in a new edition of their pyrometer catalog a new two- and three-position recorder-controller. The complete Tag line of indicating, recording, and controlling pyrometers, which utilize a beam of light, a mirror galvanometer and a phototube, is also described. Bulletin Ay-62.

Capacitrol

An indicating control pyrometer is made by Wheelco Instruments Co., known as the Wheelco Capacitrol. Their bulletin gives full description, wiring diagrams for different furnace or oven installations, and price. Bulletin Mya-110.

Some of the Best Thinking

in the metal industries is at your disposal in the literature described here. One booklet may hold the key to your current problem. Help yourself to this helpful literature. It's free. You incur no obligation when you return the coupon.

Recuperators

Results obtained with Carborundum Company's recuperators using Carbofrax tubes are fuel savings, closer temperature control, faster heating, and improved furnace atmosphere. Complete engineering data are given in Bulletin Fx-57.

Aluminum Finishes

Good printing, good paper, spiral binding and an attractive presentation add interest to the valuable technical information on "Finishes for Aluminum" contained in Aluminum Co. of America's new booklet. Bulletin Oy-54.

Alloy Steels

Why alloy steels are best for heavy equipment and other exacting applications is discussed in a folder by Bliss & Laughlin, Inc. A partial list of the more common grades gives machine ratings and turning speeds. Bulletin Jyb-42.

Machining Stainless

Don't let machining problems keep you from using stainless steel. A booklet by U. S. Steel Corp. contains full information on two types of stainless steels which can be easily handled on automatic screw machines for quantity production. Bulletin Ny-79.

Welding Technique

A new arc welder has been designed by Lincoln Electric Co. in which the heat of the welding arc can be varied as to type as well as to intensity. A book giving full details of this new dual continuous control is ready for distribution. Bulletin Ny-10.

Stainless Data Book

All users of stainless and heat resisting alloys should find invaluable the information contained in a booklet published by Maurath, Inc. giving complete analyses of the alloys produced by the different manufacturers, along with the proper electrodes for welding each of them. Bulletin Jyb-125.

Cutting Steel

Recommended practices for gas cutting of structural steel are given in a concise and authoritative form by The Linde Air Products Co. Qualification tests for good workmanship from the standpoint of accuracy and smoothness of cuts are also described. Bulletin Dc-63.

New-Series Recorders

Foxboro's new bulletin describes in detail the extra, compensating slide-wire — a feature found only in the Foxboro potentiometer recording pyrometers for industrial temperatures. All types are listed and illustrated in this booklet. Bulletin Myb-21.

Gas Carburizing

Surface Combustion Corp. shows how five years of use have proven the Eutectrol process of continuous gas carburizing to give better control of case depth and character, along with large savings in cost. Bulletin Oy-51.

Nichrome

"Nichrome" nickel-chromium resistance alloy is not the only product made by Driver-Harris Co. A new 68-page catalog gives complete data for this well-known material as well as a wide variety of other alloys. Bulletin Oy-19.

Pure Metals

Pure, carbide-free metals are described and applications suggested in a pamphlet published by Metal & Thermit Corp., who make pure tungsten, chromium and manganese in addition to the ferro-alloys. Bulletin Mya-64.

Specialized Tester

The Rockwell superficial hardness tester is a specialized instrument for use where the indentation into the work must be kept shallow or of small area, yet sensitivity preserved. A supplement to Wilson Mechanical Instrument Co.'s catalog on the regular Rockwell tester tells all about it. Bulletin Sy-22.

Nickel-Copper Steels

Exceptional resistance to corrosion and abrasion, increased tensile strength, and higher ductility are the qualities claimed for Youngstown Sheet & Tube Co.'s new series of Yoloy steels. A summary of properties and notes on their characteristics are contained in Bulletin Ox-93.

Metalliput

A new inverted universal microscope designated the "Metalliput" is described in a leaflet by Carl Zeiss, Inc. It can be used for bright and darkfield metallography and macrography and is convertible for use with transmitted light. Bulletin Sy-28.

Moly Cast Iron

The use of molybdenum in foundry practice, both on steel and cast iron, is described in a handsome booklet by Climax Molybdenum Co., which presents accurate technical information in a striking and modern manner. Bulletin Jyc-4.

Cutting Oils

The problems of machine tool lubrication engendered by the high speed production and close tolerances of modern industrial operations are discussed and progress in cutting oils during the past few years reviewed in a booklet by D. A. Stuart & Co. Bulletin Jyb-118.

Globar Elements

Globar electrical heating units and a variety of accessories for their operation have been catalogued by Globar Division of Carborundum Co. Bulletin Oy-25.

Tocco Process

This amazing new and extremely accurate method of heat treating is described in a new four-page leaflet, yours for the asking. Distributed by Ohio Crankshaft Co. Bulletin Oy-145.

Screw Machine Stock

Union Drawn Steel Co. makes cold drawn steels expressly for efficient automatic screw machine operations. Why they are efficient is explained in an attractive folder. Bulletin Dy-83.

Centrifugal Casting

A new circular has been prepared by the Calorizing Co. describing their methods of centrifugal casting. Bulletin Dy-26.

Furnace Control

How the Lindberg Control functions in balancing the rate of heating of a furnace or oven with the varying heat requirements is told in an attractive new bulletin issued by Lindberg Engineering Co. Bulletin Myb-66.

Corrugated Ingots

The Gathmann Engineering Co. has published a new booklet called "Gathmann Ingot Molds — Their Purpose and Design." It illustrates various corrugated ingot contours designed to produce defect-free surface in steel ingots. Bulletin Aya-13

Heat Resisting Alloys

Authoritative information on alloy castings, especially the chromium-nickel and straight chromium alloys manufactured by General Alloys Co. to resist corrosion and high temperatures, is contained in Bulletin D-17.

Ni-Cr Castings

Compositions, properties, and uses of the high nickel-chromium castings made by The Electro Alloys Co. for heat, corrosion and abrasion resistance are concisely stated in a handy illustrated booklet. Bulletin Fx-32.

Alloy Castings

Michiana Products Corp. has published a new book describing Michiana corrosion resistant and stainless steel alloys. Generously illustrated, it suggests many savings for the use of these alloys. Bulletin Oy-81.

Testing with Monotron

Shore Instrument & Mfg. Co. offers a new bulletin on Monotron hardness testing machines which function quickly and accurately under all conditions of practice. Bulletin Je-33.

Newer Tool Steels

Vulcan Crucible Steel Co. has a complete and attractive catalog listing their full line of tool steels including many special types to meet the modern trends in industry. Bulletin Jyb-127.

Heat Treating Manual

A folder of Chicago Flexible Shaft Co. contains conveniently arranged information on heat treating equipment for schools, laboratories and shops, and also illustrates the several types of Stewart industrial furnaces. Bulletin Ar-49.

Port Valves

Diagrams and descriptive matter show the operation of adjustable port valves made by North American Mfg. Co. that are particularly suitable for mediums whose rate of flow is not constant. Bulletin Oy-138.

Lubrication Research

An issue of E. F. Houghton & Co.'s new publication, "Research Illustrated," is devoted to lubrication. It is a fine pictorial presentation of the practical problems of lubricating intricate, high speed, modern machinery. Bulletin Oy-38.

Tool Steel Catalog

A new catalog lists and describes the complete line of tool steels manufactured by Columbia Tool Steel Co. Bulletin Mya-115.

Compressors

B. F. Sturtevant Co. has a line of centrifugal compressors designed particularly for industrial furnace applications. These are illustrated and described in Bulletin Myx-58.

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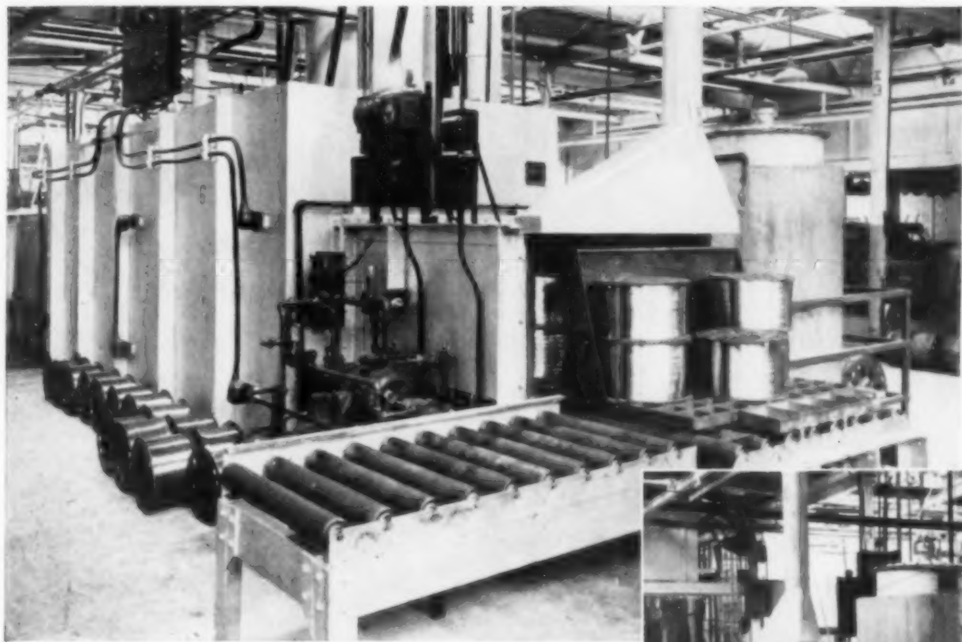

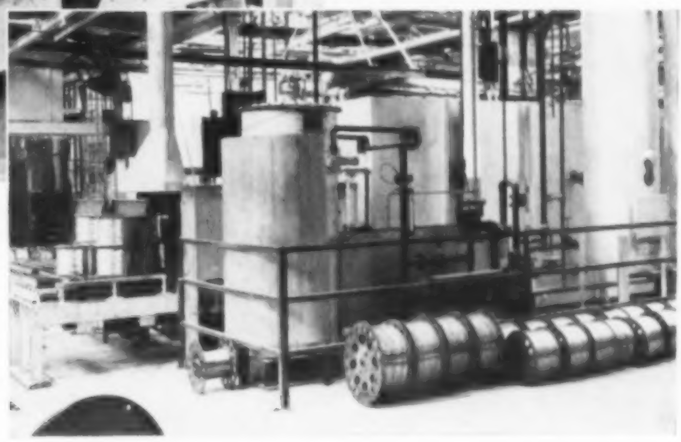

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Pusher Type Furnace for

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Uniformly, Economically and Continuously

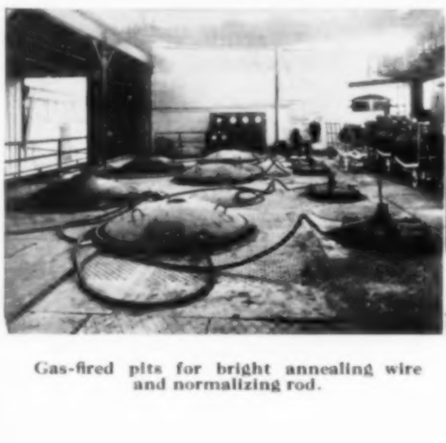
Wire from the finest gauges to the heaviest sizes is bright annealed uniformly, economically and continuously in the special atmosphere, recuperative, pusher type furnace shown above.

Coiled wire, as well as wire on small spools and large reels, is successfully handled in this equipment. No water seals or vapor of any kind is used, thus staining is entirely eliminated and no drying necessary. The wire is discharged from the furnace uniformly annealed, absolutely bright and dry, ready for shipping, further processing or fabricating. This is one of several types of electric and fuel-fired furnaces we have developed and built for the wire industry.

Other recent installations include furnaces for bright and clean annealing brass and copper wire, improved pit type furnaces for normalizing rod and bright annealing steel in coils, as well as furnaces for scale-free hardening bolts, springs, etc., billet heating, bright annealing tubing, strip, stampings; carburizing, copper brazing and other heating and heat treating processes.

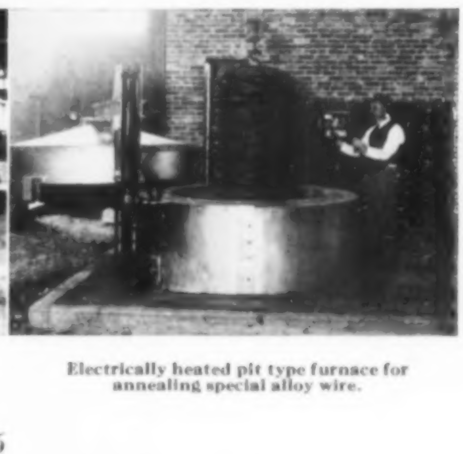
If you are interested in improving the quality of your anneal or heat treatment, increasing production or are contemplating any changes or additions to your furnace equipment, our engineers will be glad to work with you. We specialize on building production furnaces to fit the customer's specific requirements.

The Electric Furnace Company, Salem, Ohio



Gas-fired pits for bright annealing wire and normalizing rod.

Continuous conveyor type, gas-fired furnace clean annealing wire in coils.



Electrically heated pit type furnace for annealing special alloy wire.